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RADON AND INDOOR AIR POLLUTION

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HEARING

BEFORE THE

SUBCOMMITTEE ON NATURAL RESOURCES, AGRICULTURE RESEARCH AND ENVIRONMENT

OF THE

COMMITTEE ON SCIENCE AND TECHNOLOGY U.S. HOUSE OF REPRESENTATIVES

NINETY-NINTH CONGRESS

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RADON AND INDOOR AIR POLLUTION

THURSDAY, OCTOBER 10, 1985

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
SUBCOMMITTEE ON NATURAL RESOURCES,
AGRICULTURE RESEARCH AND ENVIRONMENT,
Washington, DC.

The subcommittee met, pursuant to notice, at 2:04 p.m., in room 2325, Rayburn House Office Building, Hon. James H. Scheuer (chairman of the subcommittee) presiding.

Mr. SCHEUER. The Subcommittee on Natural Resources, Agriculture Research and Environment will come to order.

This afternoon, the committee will hear witnesses and examine the emerging environmental and public health problem known as indoor radon radiation. It is a pollution problem really unlike any other.

First of all, of all the forms of pollution that we know about, this pollution is not man-made. It comes from nature. As we all know, nature in the raw is seldom mild for those above 50, correct? We cannot detect it with our senses. It is odorless, colorless, and tasteless. It is invisible. And it is a killer.

It is the most dangerous of the radiation effects of any pollution, and, apart from cigarette smoking, it is the No. 1 cause of lung cancer in this country, after cigarette smoking. Approximately 20,000 people a year die of the radiation poison emanating from radon exposure. It may be the most lethal pollution effecting the American population. We think that it causes more deaths than all other forms of radiation pollution in the outdoor air.

Radiation from radon, indoor air pollution, in a million homes in this country produces approximately a 2-percent statistical likelihood of getting cancer in a lifetime. This may seem small, but that compares with one in a million chances of getting cancer from other forms of radiation pollution in the outdoor air.

Now, thinking is beginning on the problem of radiation exposure in the executive agencies. The Department of Energy and the EPA are responding. They are particularly responding as a consequence of what we have learned about the Reading Prong in Pennsylvania, which is an underground rock formation that extends through Pennsylvania and into New Jersey, as I understand it, and we will hear from those two agencies today about their plans.

We will hear from some citizens who have been affected by radon, and we will deal with some other experts and other Federal and State officials about what they are going to do about radon.

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We also expect to have two distinguished U.S. Senators, Senators Mitchell and Lautenberg, here before very long. They have made some very helpful suggestions. They are sponsoring our legislation on the Senate side and have included our legislation as an amendment to Superfund reauthorization, which has recently passed the Senate. I want to congratulate them for their leadership, and we look forward to their appearance here in the next few minutes.

We also expect Congressman Gus Yatron, Congresswoman Marge Roukema of New Jersey, and Congressman Jim Courter of New Jersey, who have been invited by myself and by the distinguished ranking minority member, Claudine Schneider of Rhode Island, because of their concerns about radon in the Reading Prong.

And now I would like to introduce my distinguished colleague and ranking Republican member of this committee, Claudine Schneider of Rhode Island, and I want to say how much we all owe her for the leadership work that she has done and the constant pushing and prodding and imagination and drive that she has invested in this radon matter from the very beginning.

She has given us an object lesson in what a ranking minority member can do with the requisite imagination and commitment on a subject of concern to her, and she is no less responsible than myself or anybody else for the fact that we are having this hearing today and that we are at this point in the legislative process that we are at today.

Congresswoman Schneider.

Mrs. SCHNEIDER. Thank you, Mr. Chairman.

I will admit that, on occasion, when my colleagues have said to me, "Claudine, what is this? I hear you are working on indoor air pollution," and my response has been, "Yes, it could be a very critical and extremely serious problem," the response that I have gotten is laughter. People think, Oh, indoor air; you had to go and invent that, Claudine. Don't we have enough dealing with outdoor air pollution?

But the fact of the matter is—and I think that is attested to by those of you who are here today—that there is a potential problem, and we are finding out to what degree and how expansive that problem is by the Congress making sure that appropriate monies are available for the Environmental Protection Agency to do the amount of research that is necessary to determine the breadth and scope of the radon problem.

It is estimated that anywhere from 12,000 to 20,000 lung cancers a year are attributable to radon exposure and indoor air pollution exposure, but yet it is very frustrating in that a comprehensive effort to assess the extent of the radon problem or exactly how to deal with it in terms of mitigating measures is still rather fluid.

We were successful in passing out of our own full committee legislation that is a direct response to this radon problem. I am happy to convey that, in the past, we have been able to slip this money through in the Appropriations Committee to make sure that there was adequate funding for research.

This year we have our very own special bill that highlights the problem, and I am optimistic that we will see as a result of that a greater enthusiasm on the part of the Environmental Protection Agency and also, in particular, on the part of the Office of Manage-

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ment and Budget to assure that we can proceed with the amount of research and the depth of research that I believe is very necessary.

Unfortunately, Members of Congress are always referred to as leaders. I have a tendency to think that oftentimes we are followers. We wait until the crisis occurs and then we act.

The purpose of this legislation, and the purpose of these hearings today, is to make sure that we do not wait until the crisis becomes more severe, but rather we take a preventive medicine approach and begin some actions now.

So I am delighted, and I would like to commend my chairman for calling these hearings today, and also, I think that the variety of the witnesses that we will be hearing from will give us an overall view of the problem and, hopefully, some of the recommended solutions.

So thank you, Mr. Chairman.

Mr. SCHEUER. Thank you, Madam Congresswoman.

And now Don Ritter of Pennsylvania, the State from which much of this problem arises. Congressman Ritter?

Mr. RITTER. Thank you, Mr. Chairman, and I would like to thank you for agreeing to hold this important hearing.

The Lehigh Valley, which I represent, is situated directly on the so-called Reading Prong. It is an area where naturally occurring traces of radium and uranium are prevalent. Our experts appearing today will likely explain how radon is a decay product of these radioactive substances.

Now, over the past months, I and a number of my colleagues representing districts on the Reading Prong—notably Congressman Yatron and nearby Congressman Edgar—have been deeply involved in the matter of radon gas and its possible adverse health risks.

However, the problem is not limited to the Reading Prong. So far, homes with elevated radon levels have also been found in Maryland, New Hampshire, Maine, Florida, Idaho, Montana, North and South Carolina, Georgia, Texas, California, and Washington State.

Since there has not been a national survey with regard to radon, this may be only a portion of the States affected in this country. This brings up the question of how many other States could be affected and at what levels.

Back in May of this year, I wrote a letter to the EPA's Air and Radiation Office requesting that they lead a study to provide Congress with information to help our constituents deal effectively with the problem of radon gas in their homes. Because of the scope of the problem, I have suggested that the resources of the Government agencies which deal with this and similar problems be tapped.

So, along with EPA, the National Council on Radiation Protection and Measurements and the Department of Energy, two of the agencies that I mentioned in my letter, will be represented here today, and I look forward to hearing from them.

The main thrust of my letter to EPA, however, was for the study to address: one, assessing the risk of lung cancer posed by the indoor exposure to radon; two, developing effective low-cost measures to limit radon concentration in houses; and, three, recom-

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mending important steps in a Federal effort to identify areas of the country which present the potential for elevated indoor radon levels.

What I requested in my letter has been turned into the substance of a Senate amendment offered by the Senator from New Jersey, Mr. Lautenberg, and Senator Mitchell from Maine. That was to the Superfund bill. There is a House side legislative proposal which flowed from the Senate amendment, introduced by my colleague from Pennsylvania, Mr. Edgar.

I would also like to thank today's witnesses for taking time out of their busy schedules to share their knowledge and experience. Before us today we have a "Who's Who on Radon." I am pleased to see Drs. Wilson and Cohen, whom I have worked with personally on radon and general risk assessment and management problems. In fact, Dr. Wilson and Dr. Cohen came to the Lehigh Valley at my request this summer to present a successful seminar on the risks of radon gas.

I would especially like to thank Mr. Richard Barnola, who agreed to testify on fairly short notice on how a radon problem might affect business and real estate markets. He will tell us of his experiences in trying to sell homes in the Reading Prong area.

I look forward to hearing from this wide range of witnesses who will be presenting testimony this afternoon, those who have actual radon problems in their homes and those in State and Federal Government agencies charged with protecting the public welfare; and from those in the scientific community who attempt to find ways to reduce risks.

I would like to call attention before I close to two articles that appeared in today's papers, one in the Wall Street Journal, an editorial entitled "Countering Radon Menace is an Inside Job," and I would like, Mr. Chairman, if that is possible, to have this inserted in the record.

Mr. SCHEUER. Without objection, it is so ordered.

[The article follows:]

[From the Wall Street Journal, Oct. 10, 1985]

COUNTERING RADON MENACE IS AN INSIDE JOB

(By N.E. Hager, Jr.)

Last week's Supreme Court decision allowing the restart of the undamaged reactor at Pennsylvania's Three Mile Island nuclear plant marked the culmination of a gross misdirection of public concern about nuclear radiation. While so much energy and emotion have been spent debating the potential radiation hazards of the 1979 TMI accident, a far more serious nuclear radiation problem—radon gas—has been largely ignored by both the media and public.

The nation's number-one nuclear radiation problem is caused by naturally occurring radon gas in homes. During the past six years when TMI became the focus of so much concern, radon gas has quietly, insidiously caused at least 60,000 cases of lung cancer. The tiny amount of radiation that I and the two million other residents living near TMI received is painted as a health catastrophe—while the average American is exposed to radon doses every year averaging thousands of time more.

Both odorless and colorless, radon gas is a radioactive gas produced when radium decays. Radium, in turn, is a decay product of uranium that exists virtually everywhere in the earth's crust. Radon gas is ubiquitous in measurable quantities, seeping into houses through cracks and pores in foundations. Fortunately, the radon gas seepage into homes can be largely eliminated by proper planning of new construction and the common-sense modification of existing houses. The most dangerous

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house yet discovered—located in an area of Pennsylvania where high concentrations of radon exist—was found to have a radon level 675 times higher than the maximum permitted in a uranium mine. The same house has now been made safe enough for its occupants to return. Such successes give hope that thousands of future lung cancers can be avoided.

The National Council on Radiation Protection, a congressionally chartered body of leading scientists, has declared that radon is responsible for "the most significant [nuclear radiation] exposure of the U.S. population." The NCRP estimates the radon doses received by U.S. residents average about 3,000 millirems each year, with the effect concentrated chiefly in the bronchial tissues. (It takes about 200 chest X-rays to expose the lungs to a dose so large.)

The seriousness of the radon health threat was known at least as early as 1979, when scientists from Lawrence Berkeley Laboratories estimated that up to 20,000 cases of lung cancer a year could result from exposure to household radon in the U.S. Most recent studies confirm a range of between 10,000 and 20,000 cases a year. The lower estimate of 10,000 cancer cases a year nationwide would represent a figure of 500 a year in Pennsylvania alone, and 80 a year for the two million people living within 50 miles of TMI. Therefore, natural radon has caused about 480 lung cancers in that area during the six years since the accident. By way of comparison, a presidential commission chaired by John G. Kemeny, president of Dartmouth University, reviewed all data relating to the TMI accident and agreed with earlier conclusions that the average dose of radiation received by TMI residents was 1.5 millirems and that only one added case of cancer could theoretically develop over the next 20 years as a result of the accident.

One wonders how public-health crusaders can justify focusing so little attention on the continuing toll in human life caused by radon. Why have vast resources been spent on extended health and engineering studies, artificially prolonged regulatory and judicial proceedings and redundant power-plant modifications without proportionate attention being given to the radon problem? One excuse given is that radon is a natural phenomenon and nothing can be done about Mother Nature. This is hogwash on three counts.

First, most health hazards can be avoided or reduced if people are *aware* of them. It is no surprise that people don't worry about a problem as serious as radon if they are unaware of the existence of the gas (the Environmental Protection Agency is to be commended for finally announcing last month that it would conduct a nationwide survey to determine the extent of the radon problem).

Second, although it is true that Mother Nature is the source of radon, people can control the radon level in their homes. For example, radon concentrations are increased when ventilation in the home is decreased through conservation measures.

Third, if such measures are essential or already in place there are a variety of actions that can reduce radon levels. For new houses, building sites should be selected to avoid high concentrations of uranium or radon. Thick, nonporous concrete foundations should be used, and the use of porous blocks avoided. For older homes, commercial detection devices are available (though they require expert interpretation) for checking indoor radon levels. If levels are found to be unacceptably high, remedial procedures can include ventilating the house (taking into account the associated increased energy use), sealing up cracks and pores in the foundation and, when necessary, ventilating crawl spaces. A more costly but sometimes necessary measure would vent the region beneath the basement floor in order to redirect the radon gas away from the living space to the outdoor air.

One thing is clear. The unqualified promotion of certain conservation practices exacerbates the radon problem. Sealing up buildings to conserve warm indoor air may reduce the heating bill, but it also traps radioactive radon gas. Until techniques for mitigating this problem become generally available, the fact is that energy efficiency measures are causing the public to be exposed to increased risks from radiation. In our zeal to save energy and avoid risks from nuclear power, we cannot afford to ignore larger and even more complex risks elsewhere.

Mr. RITTER. I would also like to call attention to an article in today's New York Times which says that EPA proposes a 5-year program aimed at radioactive radon gas and, I guess, talks about the hearings that we are holding today.

[The article follows:]

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[From the New York Times, Oct. 10, 1985]

E.P.A. Proposes 5-Year Program Aimed at Radioactive Radon Gas

(By Philip Shabecoff)

WASHINGTON, Oct. 9.—The Environmental Protection Agency has proposed a national program to lessen the threat to public health from radon, a naturally occurring radioactive gas that can cause lung cancer.

The strategy aims to reduce the number of deaths attributable to radon, now estimated at 5,000 to 20,000 a year, by 35 to 50 percent.

The E.P.A. is already working closely with the State of Pennsylvania to deal with what appears to be fairly widespread radon contamination in homes built over a geologic formation, the Reading Prong, which extends from eastern Pennsylvania across northern New Jersey and into New York State. The radon is seeping into the homes from uranium in the ground below.

Radon is a colorless, odorless gas formed from the disintegration of radium that, as it decays, forms particles that can lodge in the lungs of people who breathe contaminated air. These particles, over time, can cause lung cancer. The insulation and airtight construction used to conserve energy in recent years has contributed to the concentration of radon in homes and exacerbated the health problem.

The environmental agency's national proposal, for an initial five-year program that would cost nearly $11 million, was made available today by Senator Frank R. Lautenberg, a New Jersey Democrat. The White House has not yet made a decision on the agency's plan.

PRIMARY ROLE FOR STATES

It would involve no direct regulation by Washington. The states, working with private industry, would be given the chief responsibility for reducing radon contamination inside buildings. But the Federal Government would set a "national policy" for reducing current and future exposure to radon by setting national guidelines on exposure and mitigation and by training state personnel to deal with the problem.

The E.P.A. would provide technical assistance and would also, as previously reported, conduct a national survey to determine the extent and distribution of radon contamination and pinpoint high-risk areas.

According to preliminary data collected by the agency, roughly a million homes around the country are contaminated with radon at levels that pose a significant risk of lung cancer to people who are exposed over long periods.

AUTHORITY IS AT ISSUE

At a House of Representatives hearing on radon and indoor air pollution scheduled for Thursday, Senator Lautenberg intends to release a letter from the Federal Emergency Management Agency stating that disasters attributable to radon could qualify for Federal aid under the Disaster Relief Act.

Meanwhile, the State of Pennsylvania is planning to place advertisements this weekend offering free radon tests to owners of homes built over the Reading Prong, according to Bruce Dallas, a spokesman from the state's Department of Environmental Resources. The state also intends to make $3 million available for low-interest loans to residents who need to make construction changes on their homes to protect them from radon, he said.

In testimony prepared for the hearing before a House Science and Technology subcommittee, Senator Lautenberg charges that the White House Office of Management and Budget has delayed efforts to deal with the radon problem. He intends to urge Congress to act to give the E.P.A. "the direction, authority and funding it needs to run an effective radon program."

Edwin L. Dale Jr., spokesman for the budget office, said that a budget proposal for the radon program had been submitted by the E.P.A. but that no decisions for the budget for the 1987 fiscal year had yet been reached. The budget office has taken the position in the past that the environmental agency does not have the statutory authority to regulate indoor air pollution, including radon. But the general counsel's office at the E.P.A. says such authority does exist under the Clean Air Act.

FUNDS FOR RESEARCH VOTED

Representative James H. Scheuer, the Queens Democrat who will preside at the hearing of the Natural Resources Subcommittee, said the problem of indoor air pollution was a "big one" because radon was the second leading cause of cancer after

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smoking and the leading cause among nonsmokers. He also said that the environmental agency's standards for controlling radon where inadequate and did not reflect the latest medical findings.

A bill introduced by Mr. Scheuer and others to provide $3 million over two years to do research on indoor air pollution was adopted by the full science committee but has not yet reached a floor vote. The Senate recently voted for a $3 billion indoor air research program as an amendment to the toxic waste law it voted to renew late last month.

The E.P.A. proposal for dealing with radon said the plan not only would reduce the current level of deaths due to lung cancer but would also reverse what it said was a trend leading to increased radon deaths. The plan would also ease "growing public concern about a significant environmental problem," the proposal said.

Mr. RITTER. So, Mr. Chairman, thank you for your indulgence.

Mr. SCHEUER. We are going to interrupt the opening statements up here to hear from our two distinguished Senatorial witnesses, and then we will come back to opening statements up here.

We very much appreciate your coming. We very much appreciate, Senators, the leadership you have taken on the Senate side. We are very gratified that you have included this legislation in the Superfund bill. You have successfully pinned the tail on the donkey. We are grateful for your insight and your leadership, and we look forward to hearing from you both.

Senator Lautenberg.

STATEMENT OF HON. FRANK R. LAUTENBERG, A U.S. SENATOR FROM THE STATE OF NEW JERSEY

Senator LAUTENBERG. Thank you, Mr. Chairman and members of the committee. Thank you, in particular, for recognizing the fact that we have our wrestling match continuing over on our side and, hopefully, it will be finished sometime today, and I am sure you will be watching with interest the general negotiation over there.

I commend you for holding this hearing on this important topic, radon indoor air pollution. I will try to keep my remarks short. I know that the subcommittee has a full slate of witnesses this afternoon.

I am especially pleased to join with my friend and distinguished colleague, Senator Mitchell, with whom I work so closely in the Senate on legislation. Senator Mitchell and I worked together to combine two bills as an amendment to the Senate Superfund bill that relate to the matter under discussion.

Our legislation, adopted unanimously by the Senate on September 18, addresses an issue of growing concern in our States and throughout the Nation, radon and indoor air pollution.

The Environmental Protection Agency estimates that 5,000 to 20,000 lung cancer deaths per year in the United States may be attributable to radon exposure. This means that close to one-fifth of the Nation's lung cancer deaths annually may be due to radon.

What are we doing about it? Not much. What is the holdup? It appears to be the Office of Management and Budget. OMB has got its fingerprints on it—the same OMB that refused for months to release EPA regulations to protect our drinking water, the same OMB that killed recommendations from EPA to ban asbestos, the same OMB that has extended its invisible web over innumerable health and safety regulations and stopped them dead in their tracks.

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The fact is that OMB has stymied efforts within EPA to develop a comprehensive indoor air program, including radon research. EPA has managed to conduct a limited indoor air program because of congressionally initiated funding, but OMB refuses to approve an adequate program.

In preparation of its budget request for fiscal year 1986, EPA included $2 million for radon research. This funding request, as small as it was, was eliminated by OMB and didn't appear in the President's budget submission.

In July, professional staff at EPA's Office of Radiation Programs, working with seven other program offices within EPA, prepared a strategy and management plan for assessment and mitigation of radon exposure. It was prepared at EPA Administrator Lee Thomas's request as an aid in developing a Federal strategy for dealing with the problem of radon contamination.

Mr. Chairman, I have a copy of this report with me that we are making available to the committee. In the report, EPA lays out its preferred course of action for a radon research and mitigation program and recommends that $10.775 million be committed to attack the radon problem.

EPA's estimate is that implementation of its recommendations could prevent several thousand deaths a year. Ten million dollars over 5 years is not insignificant, but with the size of budgets and with the size of programs required, it is not very much money. This would save, I point out to you once again, according to EPA, several thousand lives. Now, with the estimate that we could save 5,000 lives a year, that would be $2,000 a life.

The report has never been made available to the public by EPA. In fact, I would have to say at this point that an active effort is being made to keep it quiet, to cover up the report.

I requested the July report from EPA several times, and I never received it. Instead, let me tell you what I did receive. Yesterday, EPA's budget office finally responded to a request of mine for this report of almost 1 month's standing, and what did they give me? A truncated, sanitized version of the July report dated September 1985 which omits the budget information and a full discussion of the options that the agency reviewed.

This morning I received a letter from the Acting Administrator for Air and Radiation—his names is Elkins—which denies that EPA has an indoor radon strategy. Mr. Elkins assured me that when EPA's analysis was completed, he would send me a copy. I have two copies. They are older and they are different. And maybe I shouldn't be too hard on him, because I believe the real culprit is OMB, which has taken decisionmaking authority away from congressionally confirmed appointees who are under enormous pressure to fall in line, and I have got to say I find OMB's reaction pernicious and unacceptable.

What are the differences between these reports, the July and September versions? What has been omitted? All the budget information, all the discussion of options. Most alarming is the omission of information on health effects.

The July report states categorically that EPA's recommended program would achieve a 35 to 50 percent risk reduction—located

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on page 3—thus avoiding, and this is right out of the report, several thousand lung cancer deaths per year.

The September report omits any reference to lifesaving. It is inconceivable to me, and unacceptable, that our Government would cover up this information. That is exactly what has happened, and I do not understand why. The answer lies at OMB, as I said, and not at EPA. At OMB, they would rather save money than lives.

What did they propose in the EPA plan? EPA laid out several options for dealing with the hazard, including low, medium, and high cost options. The options differed not only in their price tags but also in the degree of responsibility assigned to the Federal Government versus State and local governments and the private sector.

In the end, EPA selected the so-called strawman strategy, which it felt was most effective. A bad title, because that always suggests that it is not an effective program. This one, we believe, is. The strategy combined elements of the others with EPA taking the lead in the early years to set Federal policy and to undertake those responsibilities best executed at the Federal level.

In later years, under this strategy, EPA would continue to provide guidance to the States but delegate those responsibilities which the States and the private sector can handle.

The strawman strategy closely follows the course set by the Mitchell-Lautenberg legislation adopted by the Senate. It calls for four steps: a national assessment of the radon threat, determining the high-risk areas; a focus of EPA resources on developing mitigation capabilities in conjunction with State and local bodies; development of guidance documents for the States on preventive techniques to eliminate radon contamination in structures; and the establishment of a national policy for reducing current and future indoor radon exposure.

Now, I understand that Lee Thomas has signed off on the strawman strategy and sent another budget request to OMB, where it has been waylaid once again. OMB has opposed a radon program in the past, and I am not optimistic about its supporting one now, although I would certainly welcome a change in its position.

Certainly a strong directive from the Congress is needed. We have a carefully prepared set of recommendations from EPA about what we need to do. The Senate Appropriations Committee has approved an amendment which I offered in committee to EPA's fiscal year 1986 R&D budget to provide $2 million for radon research and mitigation efforts. Senator Mitchell and I intend to continue to push for the most effective agency program.

Congress must do more than provide sporadic aid and incremental funding to these efforts. We have limped along like this for several years. Unless we hear some good news today, it appears to me that EPA needs our help to let them do what they want to do.

OMB has thwarted EPA efforts in the past and appears unwilling to accept EPA's recommendations and allow for the funding. We have got to move ahead and approve a program that gives EPA the direction, authority, and funding it needs to run an effective radon program.

Mr. Chairman, I commend the subcommittee for its interest in the issue, and I hope that the full House of Representatives will

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include radon provisions in its version—and I hope we get it soon—of the Superfund reauthorization bill.

Mr. Chairman, Senator Mitchell has provided real leadership in the Senate on the problem of radon and indoor pollution. He, early on, recognized the need to move forward with legislation, and he has questioned EPA nominees, including Deputy Administrator Barnes, about EPA radon and indoor air pollution research and OMB's role in thwarting EPA recommendations.

He is a leader in the Environment and Public Works Committee on so many critical environmental issues, and I look forward to his testimony. It is a privilege to serve with him.

In the interest of time, I ask unanimous consent that the remainder of my remarks be included in the record.

[The prepared statement of Senator Lautenberg follows:]

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TESTIMONY OF SENATOR FRANK R. LAUTENBERG
HEARING ON RADON AND INDOOR AIR POLLUTION
SUBCOMMITTEE ON NATURAL RESOURCES
COMMITTEE ON SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES
OCTOBER 10, 1985

THANK YOU, MR. CHAIRMAN. I COMMEND YOUR LEADERSHIP IN HOLDING THIS HEARING ON THE IMPORTANT TOPIC OF RADON AND INDOOR AIR POLLUTION. I WILL KEEP MY REMARKS SHORT, AS I UNDERSTAND THAT THE SUBCOMMITTEE HAS A FULL SLATE OF WITNESSES THIS AFTERNOON.

I AM ESPECIALLY PLEASED TO JOIN MY DISTINGUISHED COLLEAGUE, SENATOR MITCHELL, WITH WHOM I HAVE WORKED SO CLOSELY IN THE SENATE ON LEGISLATION. I JOINED HIM AS AN ORIGINAL SPONSOR OF S. 1198, THE INDOOR AIR POLLUTION RESEARCH ACT OF 1985, IN MAY. THE BILL IS VERY SIMILAR TO H.R. 2319, THE LEGISLATION APPROVED BY THE FULL COMMITTEE ON SCIENCE AND TECHNOLOGY. SUBSEQUENTLY, I INTRODUCED S. 1593, THE RADON ASSESSMENT AND REDUCTION ACT. SENATOR MITCHELL AND I THEN WORKED TOGETHER TO COMBINE THE TWO BILLS AS AN AMENDMENT TO THE THE SENATE SUPERFUND BILL.

OUR LEGISLATION, ADOPTED UNANIMOUSLY BY THE SENATE ON SEPTEMBER 18, ADDRESSES AN ISSUE OF GROWING CONCERN IN OUR STATES AND THROUGHOUT THE NATION, RADON AND INDOOR AIR POLLUTION.

THE ENVIRONMENTAL PROTECTION AGENCY ESTIMATES THAT 5,000 TO 20,000 LUNG CANCER DEATHS PER YEAR IN THE UNITED STATES MAY BE ATTRIBUTABLE TO RADON EXPOSURE. THIS MEANS THAT CLOSE TO ONE

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FIFTH OF THE NATION'S LUNG CANCER DEATHS ANNUALLY MAY BE DUE TO RADON. WHAT ARE WE DOING ABOUT THIS?

NOTHING.

WHAT IS THE HOLDUP? IT APPEARS TO BE THE OFFICE OF MANAGEMENT AND BUDGET.

THE SAME OMB THAT REFUSED FOR MONTHS TO RELEASE EPA REGULATIONS TO PROTECT OUR DRINKING WATER.

THE SAME OMB THAT KILLED RECOMMENDATIONS FROM THE ENVIRONMENTAL PROTECTION AGENCY TO BAN ASBESTOS.

THE SAME OMB THAT HAS EXTENDED ITS INVISIBLE WEB OVER INNUMERABLE HEALTH AND SAFETY REGULATIONS AND STOPPED THEM IN THEIR TRACKS.

THE FACT IS THAT OMB HAS STYMIED EFFORTS WITHIN EPA TO DEVELOP A COMPREHENSIVE INDOOR AIR PROGRAM, INCLUDING RADON RESEARCH. EPA HAS MANAGED TO CONDUCT A LIMITED INDOOR AIR PROGRAM BECAUSE OF CONGRESSIONALLY INITIATED FUNDING. BUT, OMB HAS REFUSED TO APPROVE AN ADEQUATE PROGRAM.

IN PREPARATION OF ITS BUDGET REQUEST FOR FISCAL YEAR 1986, EPA INCLUDED $2 MILLION FOR RADON RESEARCH. THIS FUNDING REQUEST WAS ELIMINATED BY OMB AND DID NOT APPEAR IN THE PRESIDENT'S BUDGET SUBMISSION.

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IN JULY, PROFESSIONAL STAFF AT EPA'S OFFICE OF RADIATION PROGRAMS, WORKING WITH SEVEN OTHER PROGRAM OFFICES WITHIN EPA, PREPARED A STRATEGY AND MANAGEMENT PLAN FOR ASSESSMENT AND MITIGATION OF RADON EXPOSURE. IT WAS PREPARED AT EPA ADMINISTRATOR LEE THOMAS' REQUEST AS AN AID IN DEVELOPING A FEDERAL STRATEGY FOR DEALING WITH THE PROBLEM OF RADON CONTAMINATION.

MR. CHAIRMAN, I HAVE A COPY OF THIS REPORT WITH ME AND HAVE MADE IT AVAILABLE TO THE COMMITTEE. IN THIS REPORT EPA LAYS OUT ITS PREFERRED COURSE OF ACTION FOR A RADON RESEARCH AND MITIGATION PROGRAM AND RECOMMENDS THAT $10.775 MILLION BE COMMITTED TO ATTACK THE RADON PROBLEM.

EPA'S ESTIMATE IS THAT IMPLEMENTATION OF ITS RECOMMENDATIONS COULD PREVENT SEVERAL THOUSAND DEATHS A YEAR.

TEN MILLION DOLLARS OVER FIVE YEARS.

THAT WOULD SAVE, ACCORDING TO EPA, SEVERAL THOUSAND LIVES.

IF WE ASSUME WE COULD SAVE 5,000 LIVES A YEAR, THAT WOULD BE $2000 DOLLARS A LIFE.

THIS REPORT HAS NEVER BEEN MADE AVAILABE TO THE PUBLIC BY EPA. IN FACT, I WOULD HAVE TO SAY, AT THIS POINT, THAT AN ACTIVE EFFORT IS BEING MADE TO COVER UP THIS REPORT.

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I HAVE REQUESTED THE JULY REPORT FROM EPA SEVERAL TIMES. I HAVE NEVER RECEIVED IT. INSTEAD, LET ME TELL YOU WHAT I HAVE RECEIVED.

YESTERDAY, EPA'S BUDGET OFFICE FINALLY RESPONDED TO A REQUEST OF MINE FOR THIS REPORT OF ALMOST ONE MONTH'S STANDING. WHAT DID THEY GIVE ME? A TRUNCATED AND SANITIZED VERSION OF THE JULY REPORT, DATED SEPTEMBER, 1985, WHICH OMITS BUDGET INFORMATION AND A FULL DISCUSSION OF THE OPTIONS THE AGENCY REVIEWED.

THEN, THIS MORNING, I RECEIVED A LETTER FROM ACTING ASSISTANT ADMINISTRATOR FOR AIR AND RADIATION ELKINS WHICH DENIES THAT EPA EVEN HAS AN INDOOR RADON STRATEGY. MR. ELKINS ASSURED ME THAT WHEN EPA'S ANALYSIS WAS COMPLETED, HE WOULD SEND ME A COPY. WELL, I ALREADY HAVE TWO COPIES. AND THEY ARE DIFFERENT.

MAYBE I SHOULDN'T BE TOO HARD ON MR. ELKINS, BECAUSE I BELIEVE THE REAL CULPRIT IS OMB. AN OMB WHICH HAS TAKEN DECISION-MAKING AUTHORITY AWAY FROM CONGRESSIONALLY CONFIRMED APPOINTEES, WHO ARE UNDER ENORMOUS PRESSURE TO FALL IN LINE. BUT, I MUST SAY THAT I FIND OMB'S REACH PERNICIOUS AND UNACCEPTABLE.

WHAT ARE THE DIFFERENCES BETWEEN THE JULY AND SEPTEMBER VERSIONS OF THE REPORT? WHAT INFORMATION HAS BEEN OMITTED?

ALL THE BUDGET INFORMATION. ALL THE DISCUSSION OF OPTIONS. BUT, MOST ALARMING, IS THE OMISSION OF INFORMATION ON HEALTH EFFECTS.

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THE JULY REPORT STATES CATEGORICALLY THAT EPA'S RECOMMENDED PROGRAM WOULD ACHIEVE A 35% TO 50% RISK REDUCTION, THUS AVOIDING SEVERAL THOUSAND LUNG CANCER DEATHS PER YEAR.

THE SEPTEMBER REPORT OMITS ANY REFERENCE TO SAVING LIVES.

IT IS INCONCEIVABLE TO ME, AND UNACCEPTABLE TO ME, THAT OUR GOVERNMENT WOULD COVER UP THIS INFORMATION.

BUT, THAT IS EXACTLY WHAT HAS HAPPENED.

WHY?

I THINK THE ANSWER LIES AT OMB AND NOT AT EPA.

AN OMB THAT WOULD RATHER SAVE MONEY THAN SAVE LIVES.

NOW, WHAT DID EPA PROPOSE IN ITS PLAN?

EPA LAID OUT SEVERAL OPTIONS FOR DEALING WITH THE HAZARD, INCLUDING LOW, MEDIUM AND HIGH COST OPTIONS. THE OPTIONS DIFFERED NOT ONLY IN THEIR PRICE TAGS, BUT ALSO IN THE DEGREE OF RESPONSIBLITY ASSIGNED TO THE FEDERAL GOVERNMENT VERSUS STATE AND LOCAL GOVERNMENTS AND THE PRIVATE SECTOR.

IN THE END, EPA SELECTED THE SO-CALLED "STRAWMAN STRATEGY," WHICH IT FELT WAS MOST EFFECTIVE. THIS STRATEGY COMBINED ELEMENTS OF THE OTHERS, WITH EPA TAKING THE LEAD IN THE EARLY YEARS, TO SET FEDERAL POLICY AND UNDERTAKE THOSE RESPONSIBILITIES BEST EXECUTED AT THE FEDERAL LEVEL. IN LATER

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YEARS, UNDER THIS STRATEGY, EPA WOULD CONTINUE TO PROVIDE GUIDANCE TO THE STATES, BUT DELEGATE THOSE RESPONSIBILITIES WHICH THE STATES AND PRIVATE SECTOR CAN HANDLE.

THE "STRAWMAN" STRATEGY CLOSELY FOLLOWS THE COURSE SET BY THE MITCHELL-LAUTENBERG LEGISLATION ADOPTED BY THE SENATE. IT CALLS FOR FOUR STEPS:

* A NATIONAL ASSESSMENT OF THE RADON THREAT, DETERMINING HIGH-RISK AREAS;

* A FOCUS OF EPA RESOURCES ON DEVELOPING MITIGATION CAPABILITIES, IN CONJUNCTION WITH STATE AND LOCAL BODIES;

* DEVELOPMENT OF GUIDANCE DOCUMENTS FOR THE STATES ON PREVENTIVE TECHNIQUES TO ELIMINATE RADON CONTAMINATION IN STRUCTURES; AND

* ESTABLISHMENT OF A NATIONAL POLICY FOR REDUCING CURRENT AND FUTURE INDOOR RADON EXPOSURE.

I UNDERSTAND THAT LEE THOMAS HAS SIGNED OFF ON THE "STRAWMAN STRATEGY" AND SENT ANOTHER BUDGET REQUEST TO OMB, WHERE IT HAS BEEN WAYLAID. OMB HAS OPPOSED A RADON PROGRAM IN THE PAST. I AM NOT SANGUINE ABOUT OMB SUPPORTING ONE NOW, ALTHOUGH I WOULD CERTAINLY WELCOME A CHANGE IN ITS POSITION.

CLEARLY, A STRONG DIRECTIVE FROM CONGRESS IS NEEDED. WE HAVE A CAREFULLY PREPARED SET OF RECOMMENDATIONS FROM EPA ABOUT WHAT WE NEED TO DO. THE SENATE APPROPRIATIONS COMMITTEE

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HAS APPROVED AN AMENDMENT I OFFERED IN COMMITTEE TO EPA'S FISCAL YEAR 1986 RESEARCH AND DEVELOPMENT BUDGET, TO PROVIDE $2 MILLION FOR RADON RESEARCH AND MITIGATION EFFORTS. AND SENATOR MITCHELL AND I INTEND TO CONTINUE TO PUSH FOR THE MOST EFFECTIVE AGENCY PROGRAM.

CONGRESS MUST DO MORE THAN PROVIDE SPORADIC AND INCREMENTAL FUNDING TO THESE EFFORTS. WE HAVE LIMPED ALONG LIKE THIS FOR SEVERAL YEARS. UNLESS WE HEAR SOME GOOD NEWS TODAY, IT APPEARS TO ME THAT EPA NEEDS OUR HELP TO LET THEM DO WHAT THEY WANT TO DO. OMB HAS THWARTED EPA EFFORTS IN THE PAST AND APPEARS UNWILLING TO ACCEPT EPA'S RECOMMENDATIONS AND ALLOW FOR FUNDING.

WE MUST MOVE AHEAD AND APPROVE A PROGRAM THAT GIVES EPA THE DIRECTION, AUTHORITY AND FUNDING IT NEEDS TO RUN AN EFFECTIVE RADON PROGRAM.

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MR. CHAIRMAN, I COMMEND THE SUBCOMMITTEE FOR ITS INTEREST IN THIS ISSUE. I HOPE THAT THE FULL HOUSE OF REPRESENTATIVES WILL INCLUDE RADON PROVISIONS IN ITS VERSION OF THE SUPERFUND REAUTHORIZATION BILL.

MR. CHAIRMAN, SENATOR MITCHELL HAS PROVIDED REAL LEADERSHIP IN THE SENATE ON THE PROBLEM OF RADON AND INDOOR AIR POLLUTION. HE EARLY ON RECOGNIZED THE NEED TO MOVE FORWARD WITH LEGISLATION. HE HAS QUESTIONED EPA NOMINEES, INCLUDING DEPUTY ADMINISTRATOR JIM BARNES, ABOUT EPA RADON AND INDOOR AIR POLLUTION RESEARCH AND OMB'S ROLE IN THWARTING EPA RECOMMENDATIONS. SENATOR MITCHELL IS A LEADER ON THE ENVIRONMENT AND PUBLIC WORKS COMMITTEE ON SO MANY CRITICAL ENVIRONMENTAL ISSUES. I LOOK FORWARD TO HIS TESTIMONY. IT IS AN HONOR TO SERVE WITH HIM.

IN THE INTEREST OF TIME, I ASK UNANIMOUS CONSENT THAT THE REMAINDER OF MY REMARKS, WHICH DEAL WITH THE SENATE APPROVED LEGISLATION, BE INSERTED IN THE HEARING RECORD.

THANK YOU.

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THE LEGISLATION ADOPTED BY THE SENATE MANDATES THAT THE EPA ADMINISTRATOR ESTABLISH A COMPREHENSIVE RESEARCH PROGRAM TO ASSESS AND COLLECT DATA ON HEALTH RISKS ASSOCIATED WITH INDOOR AIR POLLUTANTS, METHODS FOR MEASURING INDOOR AIR POLLUTANTS, AND CONTROL TECHNOLOGIES AND MITIGATION MEASURES. THE EPA IS ALSO CHARGED WITH DEMONSTRATING MITIGATION MEASURES, A TASK THAT IT HAS ALREADY STARTED TO UNDERTAKE IN EIGHTEEN HOMES IN PENNSYLVANIA. TOGETHER WITH THE SECRETARY OF HOUSING AND URBAN DEVELOPMENT, EPA WOULD RESEARCH METHODS FOR PREVENTING RADON CONTAMINATION IN NEW CONSTRUCTION.

IN ADDITION, THE ADMINISTRATOR OF EPA IS DESIGNATED TO SERVE AS THE COORDINATING MEMBER OF INTERAGENCY EFFORTS IN THIS AREA, AND ESTABLISH A "BLUE RIBBON" ADVISORY COMMITTEE, COMPOSED OF MEMBERS OF THE SCIENTIFIC COMMUNITY, THE STATES, AND OTHER PARTIES.

THE ADMINISTRATOR IS REQUIRED TO REPORT, IN CONSULTATION WITH THE ADVISORY COMMITTEE, WITHIN TWO YEARS TO CONGRESS A SUMMARY OF THE STATE OF KNOWLEDGE OF THE INDOOR AIR POLLUTION AND RADON PROBLEM, THE NEED FOR FURTHER STUDY, AND POSSIBLE MITIGATION MEASURES. ALSO INCLUDED IN THIS REPORT WOULD BE AN ASSESSMENT OF THE EXTENT OF THE HAZARD ON A NATIONAL BASIS.

THE ADMINISTRATOR IS ALSO CHARGED WITH ISSUING AN INTERIM REPORT WITHIN ONE YEAR THAT WOULD PROVIDE A PRELIMINARY IDENTIFICATION OF LOCATIONS AND AMOUNTS OF RADON IN STRUCTURES ACROSS THE UNITED STATES. THE REPORT WOULD ALSO REQUIRE THAT THE AGENCY ISSUE GUIDANCE AND INFORMATION MATERIALS BASED ON METHODS

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FOR MITIGATING RADON. FINALLY, THE LEGISLATION PROVIDES $3 MILLION IN EACH OF THE FISCAL YEARS 198

6 AND 1987 FOR EPA TO CONDUCT THIS RESEARCH.

THE VERY SERIOUS NATURE OF THE HAZARDS OF INDOOR AIR POLLUTION DEMAND THAT WE EMBARK ON A COMPREHENSIVE, NATIONAL PROGRAM TO RESEARCH THE HAZARDS OF INDOOR AIR POLLUTION.

IN THE MEANTIME IT IS IMPERATIVE THAT CITIZENS TAKE ALL AVAILABLE STEPS TO MEASURE AND REDUCE THEIR EXPOSURE TO DANGEROUS INDOOR AIR POLLUTANTS SUCH AS RADON. STATES MUST ALSO MAKE EVERY EFFORT TO HELP THEIR CITIZENS IN THIS TASK. THROUGH THE FEDERAL EMERGENCY MANAGEMENT AGENCY, STATES ARE ABLE TO APPLY FOR DISASTER RELIEF ASSISTANCE THROUGH THE DISASTER RELIEF ACT. THIS ASSISTANCE CAN INCLUDE TEMPORARY HOUSING, GRANTS AND LOW-INTEREST LOANS.

I ASK THAT A LETTER FROM THE GENERAL COUNSEL AT FEMA BE INCLUDED IN THE RECORD FOLLOWING MY COMMENTS. THIS LETTER CONFIRMS THAT RADON CAN BE ADDRESSED BY THE AGENCY THROUGH THE DISASTER RELIEF ACT OF 1974. IT IS MY HOPE THAT STATES AND LOCALITIES WILL, WITH THE AID OF THE INTERIM REPORT ISSUED BY EPA, BE AGGRESSIVE ABOUT IDENTIFYING AND MITIGATING RADON EXPOSURE IN RADON "HOTSPOTS", AND APPLY FOR DISASTER ASSISTANCE IF THEY ARE UNABLE TO MEET THE NEEDS OF THEIR CITIZENS.

THIS IS A MATTER OF SERIOUS CONCERN THROUGHOUT OUR NATION. I COMMEND THIS SUBCOMMITTEE FOR HOLDING THESE HEARINGS. I HOPE THE SUBCOMMITTEE AND THE FULL HOUSE OF REPRESENTATIVES WILL MOVE

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TO INCLUDE RADON LEGISLATION IN ITS VERSION OF THE SUPERFUND REAUTHORIZATION BILL.

MR. CHAIRMAN, SENATOR MITCHELL HAS PROVIDED REAL LEADERSHIP IN THE SENATE ON THE PROBLEM OF RADON AND INDOOR AIR POLLUTION. HE EARLY ON RECOGNIZED THE NEED TO MOVE FORWARD WITH LEGISLATION. HE HAS QUESTIONED EPA NOMINEES, INCLUDING DEPUTY ADMINISTRATOR JIM BARNES, ABOUT EPA RADON AND INDOOR AIR POLLUTION RESEARCH AND OMB'S ROLE IN THWARTING EPA RECOMMENDATIONS. SENATOR MITCHELL IS A LEADER ON THE ENVIRONMENT AND PUBLIC WORKS COMMITTEE ON SO MANY CRITICAL ENVIRONMENTAL ISSUES. I LOOK FORWARD TO HIS TESTIMONY. IT IS AN HONOR TO SERVE WITH HIM.

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HEALTH RISKS DUE TO RADON IN STRUCTURES

A Strategy and Management Plan for Assessment and Mitigation

July 23, 1985

Prepared by:

Office of Radiation Programs
U.S. Environmental Protection Agency

In Conjunction With:
Office of Research and Development
Office of Solid Waste and Emergency Response
Office of Policy, Planning, and Evaluation
Office of General Counsel
Office of Drinking Water
Office of External Affairs
Outreach and Economic Incentives Staff

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HEALTH RISKS DUE TO RADON IN STRUCTURES

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HEALTH RISKS DUE TO RADON IN STRUCTURES

Executive Summary

Purpose of Document

Elevated concentrations of radon, a naturally-occurring radioactive gas, have been found in homes across the United States. Because of the magnitude of the potential risks involved, this environmental problem has received growing public and Congressional attention. This document is to serve as a tool for Agency decisionmakers to use in developing an EPA strategy for addressing the problem of indoor radon.

Issues to be Addressed

(1) What are the exposures and risks from indoor radon?
(2) How can exposure to radon in existing structures be reduced?
(3) How can elevated radon levels in new structures be prevented?
(4) How should program direction and leadership be provided?

For each of these four issues, three alternative goals are presented. The difference among the three alternative goals is related to the magnitude and focus of the Agency's efforts on indoor radon.

"Strawman" Strategy

An example of one possible combination of alternative goals is provided on which an implementation and management plan is based. This combination is:

Issue 1: Determine the National Exposure Distribution and Identify High Risk Areas
Issue 2: Develop Mitigation Capability in States and the Private Sector
Issue 3: Provide States with Guidance on Preventive Techniques
Issue 4: Establish a National Policy for Reducing Current and Future Indoor Radon Exposure

The choice of these alternative goals is based on a recognized need to fully characterize the nature and extent of the indoor radon problem and to have the Agency adopt a strong role in establishing a cooperative risk reduction program with the States and the private sector. No direct regulatory program is envisioned.

Program Objectives

Immediate Objectives (within six months):

- Coordinate current Federal involvement in Pennsylvania
- Coordinate Federal response to Congressman Ritter's request for information on indoor radon
- Determine emergency criteria for applying CERCLA funds to naturally-occurring events
- Remediate those areas which present an environmental emergency

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Short-term Objectives (six-twelve months):

- Identify the potential for high-risk areas
- Disseminate existing information to the public on risk, control techniques, etc.
- Enhance measurement capabilities in States
- Encourage private sector development of mitigation methods

Long-term objectives (beyond one year):

- Provide criteria for determining high risk lands
- Demonstrate low-cost mitigation methods
- Expand measurement capabilities of States
- Provide health guidelines
- Inform public and industry on measurement techniques, mitigation methods, and preventive construction techniques
- Define distribution of risks in the United States

Total EPA Resource Requirements

Year	FTE	EXS
1	30.3	3,200,000
2	30.3	2,975,000
3	27.3	2,250,000
4	21.8	1,450,000
5	16.8	900,000

Environmental Benefits

- 35 - 50 percent risk reduction achievable by the "strawman" strategy, thus avoiding several thousand lung cancer deaths per year
- Reversal of current trend which is leading to increasing radon levels and risks inside structures
- Easement of growing public concern about a significant environmental problem

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I. Introduction

Recently, the problem of high indoor concentrations of radon and its decay products has received growing public and Congressional attention. Discovery of extremely harmful levels of this indoor air pollutant in homes in the Boyertown, Pennsylvania, area has highlighted the need for a coordinated Federal and State approach to mitigating this significant health hazard. In the past four months, the Administrator has been briefed twice on this issue--in April as a subpart to a general briefing on indoor air quality, and last month, in a session dealing exclusively with indoor radon.

In this latter briefing, Administrator Thomas asked the Office of Radiation Programs to take the lead in developing an integrated Agency strategy and management plan to approaching this issue. This document is the response to that request and represents a coordinated effort among various EPA offices, including the Office of Research and Development (ORD), the Office of Solid Waste and Emergency Response (OSWER), the Office of Policy, Planning, and Evaluation (OPPE), the Office of General Counsel (OGC), the Office of Drinking Water (ODW), the Office of External Affairs (OEA), and the Office of Outreach and Economic Incentives staff (OEI) in the Office of Air and Radiation. This document outlines the key elements and options to be considered in deciding an Agency strategy to assess and mitigate radon concentrations in structures.

In developing this document, we generally followed the format for strategic planning presented at the Regional Administrators' meeting in June. A review of the problem and Agency activities is followed by a discussion of four major aspects of the indoor radon problem. For each issue, alternative goals are described. A "strawman" strategy consisting of one set of alternative goals is presented, followed by implementation and management plans which describe specific tasks, resource requirements, and the responsibilities of interested Agency offices based on the "strawman" strategy. The implications of choosing different strategies are also discussed.

II. Review of the Problem

Radon, a naturally-occurring radioactive gas, is generally recognized as a key pollutant in the indoor environment. Radon is produced from the radioactive decay of radium-226, which occurs naturally in almost all soils and rocks. While the concentration of radon in the outdoor environment does not usually pose a significant health hazard, the indoor concentration can be several thousand times higher than outdoors.

The rate of entry of radon into a structure and the air exchange rate influence the radon concentration inside the structure. Radon will concentrate in indoor environments because of the limited exchange rate between indoor and outdoor air. In many buildings, the most significant pathway of radon entry is migration from soil into the structure through the basement or foundation. The rate of radon entry is affected by many factors, including radium content of the soil near a structure, soil

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moisture and porosity, and structure type. The variability of all these factors contributes to the wide distribution of radon concentrations that have been observed in homes in the United States.

The hazards posed by increased levels of radon arise primarily from two of its short-lived radioactive decay products, polonium-218 and polonium-214. These decay products tend to adhere to dust particles or other surfaces. If inhaled, the decay products deposit in the lungs, where they undergo further radioactive decay thus exposing the surrounding tissue to alpha radiation. Such radiation exposure can lead to lung cancer.

Estimates of the risk associated with exposure to radon decay products are based on several epidemiological studies of underground miners. A very high incidence of lung cancer attributable to exposure to radon decay products has been well-documented in studies conducted in a number of countries. Mortality and exposure data have been used to calculate risk coefficients for a unit exposure to radon decay products. Concentrations of radon decay products are measured in working levels (WL)*. Cumulative exposure to the decay products is measured in terms of working level months (WLM).

Current estimates suggest that the risk of lung cancer is doubled by a cumulative exposure of 20-100 working level months. (The average national lung cancer risk is about 3 in 100.) Statistically significant increased risk of lung cancer in miners is observed for exposures as low as 80 WLM. In homes, however, measured exposure rates range from 0.02 WLM per year to over 200 WLM per year. Lifetime exposures at these rates lead to cumulative exposures ranging from about 1 WLM to over 10,000 WLM. Thus, a person's lifetime risk of lung cancer could be increased to well over one chance in two.

Several radiation protection groups have estimated the number of annual lung cancer deaths attributable to indoor radon. Since we do not know the true distribution of exposures, these estimates are based on lifetime exposure (at 75% occupancy) to the average indoor level of radon decay products (estimated to be about 0.004 WL), the number of dwellings and residents in the United States, and values for lung cancer risk coefficients. The resulting estimate of aggregate health effects over all exposure levels ranges from about 5,000 to 20,000 lung cancer deaths per year. The difference between the upper and lower values is primarily associated with the use of different unit risk coefficients by various investigators. The current U.S. mortality rate from lung cancer is about 120,000 deaths per year. Improvement in the health risk estimates depends largely on obtaining better data on the national distribution of indoor radon levels. Figure 1 illustrates the likely general shape of the distribution of indoor radon decay product levels. The dotted line in

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* A working level is defined as any combination of the short half life radon decay products which ultimately emits 1.3×10^5 million electron volts of alpha-ray energy in one liter of air.

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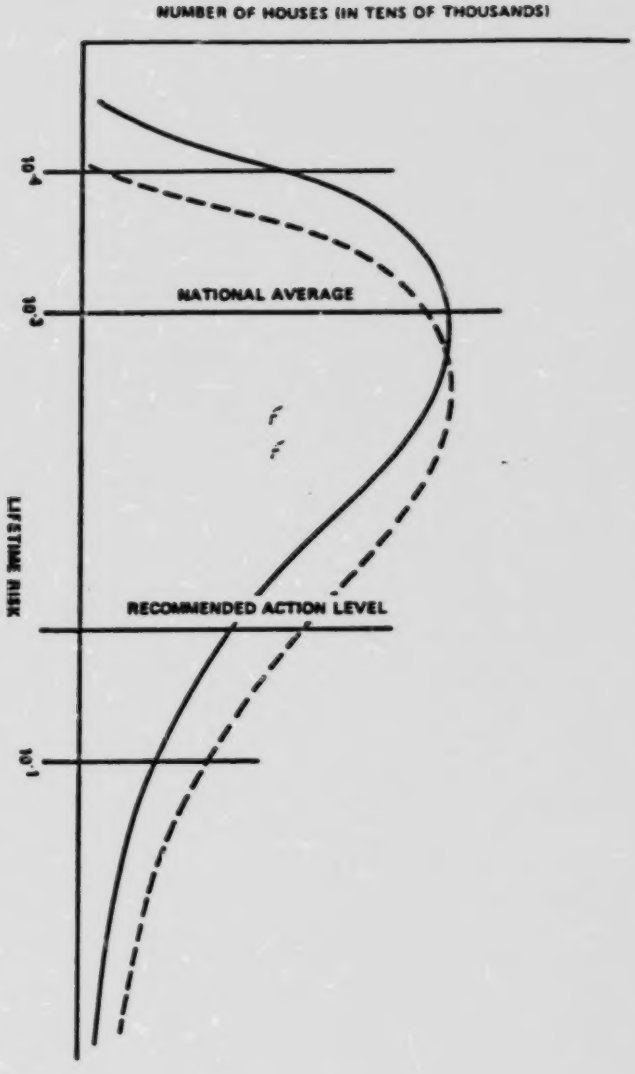

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Figure 1 indicates a shift of the distribution curve to the right which is a likely result of current building practices which may lower ventilation rates. This hypothetical curve, derived from the limited available data, demonstrates that exposure to radon decay products is likely to be associated with very large individual and total population risks in the United States.

III. Current Agency Status on Indoor Radon

Over the past 15 years, the Agency has developed a range of expertise and interests in various aspects of the indoor radon issue. Many activities resulted from programs to assist States with specific problems of elevated indoor radon levels, in such areas as Colorado, Pennsylvania, New Jersey and Florida. Other work was performed to support rulemakings under the Clean Air Act, Uranium Mill Tailings Radiation Control Act, and Safe Drinking Water Act. More recently, the Agency has begun a few projects on indoor radon with a portion of the funds provided by Congress in FY 1984 and FY 1985 for work on indoor air quality. Major areas of the Agency's past and current efforts are briefly described below; responsible program offices and extramural funding levels are provided, where appropriate.

Assistance to States: Starting in the early 1970's, EPA has responded to States' requests for technical assistance to investigate indoor radon exposure due to uranium mill tailings, phosphate ores and wastes, radium wastes, and natural sources. This assistance has included technical guidance, remediation projects, and measurement programs. Current assistance efforts include:

- Equipment loans and survey teams (ORP)
- Training and workshops (ORP and Regions)
- Sample analysis (ORP)
- Partial funding of radon study in New York (ORD, $100K - FY 1985)

Mitigation Methods: In response to the need to demonstrate control techniques and provide short-term mitigation of elevated levels, the Agency has evaluated both preventive construction techniques for new structures and remedial methods for contaminated structures. This latter activity has examined both man-made and naturally-occurring sources of contamination. Current activities, excluding Superfund actions which are separately listed, include:

- Demonstration of low-cost mitigation techniques in homes (ORD, $400K - FY 1984 and FY 1985)
- Evaluation of air cleaning methods (ORP, $100K - FY 1985)
- Technical guidance on new house designs on Florida phosphate lands (ORP)
- Pilot demonstration of radon removal from water (ORD, $32K - FY 1985)
- Survey of existing information on cost-effectiveness of alternative mitigation techniques (OPPE)

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Health Effects: In support of EPA rulemaking activities, the Agency has invested a great deal of effort in estimating the risks of cancer associated with exposure to radon. Past Agency funding for epidemiology and radiation dosimetry have contributed greatly to the current state of the art in risk assessment. Current activities include:

- National Academy of Sciences review of risk due to exposure to alpha radiation (ORP, $260K - FY 1985)
- Design and conduct of epidemiology project in Maine (ORD, $135K - FY 1984 and FY 1985)
- Computer codes and analysis for risk from radon exposure (ORP)
- Uptake and dosimetry of ingested radon (ODW, $150K - FY 1984)

Measurement Methods: The measurement of radon and its decay products has long been an area of EPA involvement. Several important measurement methods that are currently in use were developed primarily with EPA support and guidance. Current activities are:

- Development of measurement protocols (ORP)
- Development of calibration standards for radon flux measurements for soil (ORD, $50K - FY 1984)
- Quality assurance programs for radon (ORP, ORD)
- Radon emission factors from soil and water (ORD, $150K - FY 1984)
- Instrument calibration (ORP)

Policy Development: The development of policy perspectives and risk management programs have been another area of EPA involvement. The promulgation of standards for the cleanup of uranium mill tailings and the preparation of recommendations to the Governor of Florida were major exercises in this area. More recently, EPA has worked with the Centers for Disease Control to prepare criteria for removal activities under Superfund. Current activities are:

- Development of environmental emergency criteria for use of Superfund (OSWER, ORP)
- Guidance on the State of Florida's standards for indoor radon exposure from phosphate lands (ORP)
- Assistance to the State of Pennsylvania in developing risk management programs (ORP)
- Measurement of voluntary responses of Maine homeowners to information on risk and mitigation alternatives (OPPE, $10K - FY 1985)
- Monitoring Pennsylvania radon testing program and resulting impacts on housing markets (OPPE, $10K - FY 1985)
- Development of standards to limit uranium, radium, and radon in drinking water (ODW)

Superfund Actions: Remediation or removal actions involving indoor radon exposure have been conducted at several sites under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). In all cases, the CERCLA response was initiated due to radium contamination resulting from man's activities. CERCLA has not been used

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to remediate situations of contamination from naturally occurring sources. The Agency's current policy on this matter is that CERCLA removal authority may be applied in those circumstances which present a major public health or environmental emergency and in which no other group has the authority or capability to respond in a timely manner. To provide a perspective on the use of CERCLA for mitigating radon exposures, all past and present OSWER activities are listed below:

- Immediate removal action at New Jersey residences contaminated with radium-processing residue ($1.1M, ongoing at two sites)
- Immediate removal action for radium at Pennsylvania sites due to source manufacturing ($238K, ongoing at two sites)
- Removal action at Utah store contaminated with uranium mill tailings ($109K, complete)
- Removal action at Utah residences contaminated with uranium mill tailings ($231K, complete)
- Removal action at Ohio residence contaminated with radium-dial painting residues ($591K, complete)

Interagency Coordination: With the recognition that indoor radon is a national problem, the coordination of efforts among the States and Federal agencies has become increasingly important. Such coordination will serve to increase the efficiency of resource allocations and to identify specific needs of the many groups involved in the radon issue. The Agency has developed close working relationships with several agencies and groups such as the Department of Energy (DOE), the Department of Housing and Urban Development (HUD), the Committee on Interagency Radiation Research and Policy Coordination (CIRRPC), the Committee on Indoor Air Quality (CIAQ), and the Conference of Radiation Control Program Directors. The particular avenues of coordination are described in section VII of this document.

IV. Indoor Radon Program (Phase I: Selecting Goals)

At present, the magnitude and scope of the indoor radon problem are not well understood, both nationally and regionally. Further, numerous data collection and technical development efforts are needed to provide cost-effective mitigation methods and policy tools. Nonetheless, existing evidence strongly indicates that the health risks from exposure to indoor radon are significant in several areas of the country, most notably the Reading Prong area of Pennsylvania and New Jersey. We have also acquired sufficient technical knowledge to help initiate action to mitigate risks in these areas. Consequently, the Agency's future strategy to address indoor radon must build upon existing knowledge and must continue our data collection, technical development and risk assessment efforts, coupled with active programs to disseminate information and facilitate mitigation efforts.

The primary objective of our efforts to address the indoor radon problem is to reduce human exposure and risk by both reducing significant current risks and reversing trends in structure design, siting, construction, and maintenance that could increase risks in the future.

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[illegible] exposure, as well as the time frame and mechanism by which [illegible] are achieved. The options which are to be considered [illegible] need to assess the magnitude and location of the hazard [illegible].

This section describes several alternative goals for each of four major aspects of the indoor radon problem, including: 1) exposure and risk assessment, 2) mitigation of exposure in existing structures, 3) prevention of exposure in future construction, and 4) program direction and leadership. These issues were chosen to allow decisionmakers to focus on related but separable, pieces of the problem. Unique considerations exist for each aspect, and an aggressive approach to one aspect may not be necessary for another. The four issues are not intended to represent the only possibilities, but instead reflect a systematic way of examining the problem. Issue 1, exposure and risk assessment, addresses source identification and the need to determine the nature and extent of the problem and the associated risks. Issues 2 and 3, mitigation and prevention, deal with risk reduction. It is important to examine separately existing structures and new construction, since the technical and policy means of achieving risk reduction in these two instances is somewhat different and decisionmakers may choose to assign relative priorities. The fourth issue, program direction, involves the question of responsibility--who should take the lead in addressing the problem of indoor radon? In answering this question, Agency decisionmakers will ultimately be deciding the appropriate role of the Federal government in [illegible].

Three alternative goals are presented for each of the four issues [illegible]. The difference among the three goals generally is related to the magnitude and direction of the Agency's efforts on indoor radon. These alternatives are not meant to be all inclusive; clearly, there are other options available. However, in developing this document, we attempted to capture the range in program options that appear reasonable given our present understanding of the problem. The possible strategy for alleviating the indoor radon problem will be determined by the selection, for each issue, of one of the three alternative goals provided. To illustrate this process, we have developed a "strawman" strategy based on one possible combination of alternative goals: for each of the four issues, one goal is selected for inclusion in the "strawman" strategy. The reasons for its selection and a description of how it builds on current EPA activities are also described.

The presentation of the four issues is followed by an implementation [illegible] "strawman" strategy. Broad program responsibilities and approximate costs and benefits of the recommended program are presented in the management plan. We have not established an implementation plan for each combination of alternative goals as we would have been too complex and cumbersome for this document. However, to help guide [illegible] some of the possible combinations of goals, the broadest estimates of costs and benefits are provided for the universe of potential [illegible].

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Table 1

Major Issues and Alternative Goals in
Assessing and Mitigating Radon in Structures

ISSUES	(1) Exposure and Risk Assessment	(2) Mitigation of Exposure in Existing Structures	(3) Prevention of Exposure in Future Construction	(4) Program Direction And Leadership
GOAL A	Determine national distribution and identify high-risk lands	Establish Agency-led program to develop and implement mitigation techniques	Establish Agency-led program to designate high-risk lands and incorporate preventive techniques in new construction	Issue Federal guidance and recommendations on reducing exposure to radon in structures
GOAL B	Identify high-risk regions only	Focus on developing State and private sector capability to mitigate radon	Focus on providing technical and policy guidance to States and private sector on radon prevention	Develop Agency recommendations for use by States
GOAL C	Respond to States' needs to assess known problem areas	Promote private sector development of mitigation techniques	Promote development and implementation of preventive techniques in private sector	Assist State-directed programs with technical information
"Strawman" Strategy	GOAL A	GOAL B	GOAL B	GOAL A

It is important to remember that the development of this strategy is an iterative process. Periodic reassessments should be made of program direction as we gain further information. Program choices made on the basis of this document will not set the Agency on a course which cannot be changed in the future based on new insights.

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Issue 1: What are the Exposures and Risks from Indoor Radon?

- What is the magnitude of exposure to radon in U.S. homes?
- What are the sources and their relative importance?
- What are the risks and how are they distributed?
- What are the national and regional exposure and risk trends?

Alternative Goals

A: Determine the National Distribution of Risk Levels and Identify High Risk Areas

This alternative would provide a national perspective of the sources, levels and estimated health effects associated with elevated concentrations of radon in structures. Existing information on indoor radon levels is based on a fragmentary set of results from surveys conducted by different groups in scattered locations across the United States. This option provides for extensive survey efforts conducted in a representative sample of structures to better estimate individual and population exposures, to identify land and structure characteristics related to elevated radon levels, and to quantify the relative contributions to exposure from land, water, and building materials. The Agency would lead this effort and contract with States and other groups to measure levels in approximately 20,000-40,000 structures. In parallel with this effort, measurement techniques and quality control programs would be developed, and sites for epidemiology projects actively sought.

B: Identify Only High Risk Areas

This goal emphasizes a need to identify high risk regions to allow survey and mitigation efforts to be targeted first at structures in these areas. Such areas have already been found in eastern Pennsylvania, Montana, Maine, and Florida. This information will be particularly useful to States as they address the occurrence of elevated indoor radon concentrations within their boundaries. Survey designs would focus on probable indicators of radon such as underlying geology, surface soil characteristics, and water-borne radon. A perspective of the national distribution of exposure is not an objective.

C: Provide Federal Technical Assistance in Known Problem Areas

This goal focuses on responding to requests for technical assistance after a problem area has been identified. When elevated radon levels are discovered, State and individual resources are often overwhelmed by the task of assessing the sources and extent of elevated exposures. Outside of the Federal government and a few States, universities, and contractors, there are few people capable of measuring radon and its decay products. Measurement programs and response teams would be established to assist in characterizing the problem, responding to homeowner requests, and developing individual State capabilities to continue assessment efforts. In addition, the Agency would provide equipment, quality assurance checks, continued monitoring support, and public education and information

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materials. This alternative does not support an active Agency effort to identify such areas or to determine the distribution of risk levels.

Selected Goal: Alternative A - Determine the National Distribution of Risk Levels and Identify High Risk Areas

Selection of this goal would provide needed information on the distribution of radon levels inside structures across the United States and would serve to identify high risk areas of the country. Data on the national distribution of radon levels would allow us to determine the magnitude of the health risk due to indoor radon exposures. Identification of high risk areas is an important consideration in reducing risk to those individuals facing the greatest health dangers, such as homeowners in the Reading Prong. Both of these information needs are essential to reversing the national trend towards increased exposure levels and reducing the risk associated with these levels.

Currently, indoor radon levels are determined on a case-by-case basis and limited measurements have been made by a variety of groups, including DOE, EPA, the States utilities, and academia. While this information provides a sketchy picture of the conditions likely to be associated with high radon levels and a national distribution, the lack of continuity and consistency among the individual surveys makes its accuracy questionable. No attempt has been made to standardize measurement protocols and procedures. In addition, many of these surveys have been done in response to the discovery of elevated levels, and have not been intended to contribute to a determination of the national distribution.

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Issue 2: How Can Exposure to Radon in Existing Structures be Reduced?

- What role should the Federal government play in technology transfer?
- What is the appropriate Federal role in developing and demonstrating control technology?
- How much financial or technical assistance should be provided to homeowners?

Alternative Goals

A: Direct a Comprehensive Federal Program for Mitigating Structures

The focus of this alternative goal is a Federally-led and State-assisted mitigation program. There is currently no organized program for providing homeowners assistance and advice in reducing elevated radon levels in their homes. This alternative allows for large-scale demonstrations of existing mitigation methods for typical structure types, research of novel mitigation methods, provision of on-site technical guidance, and the active use of Federal funds to clean up structures with extremely elevated radon levels resulting from naturally-occurring sources. Within this alternative goal, the Agency would use to the extent possible existing Federal relief mechanisms, such as CERCLA and the Disaster Relief Act, as well as seek legislative initiatives for homeowners assistance, such as tax credits and low-interest loans. Cooperative projects with the private sector and States would be undertaken to enhance the former's capability to provide low-cost, effective control techniques.

B: Develop Mitigation Capability in States and the Private Sector Through Technology Transfer

This alternative goal focues on actively developing State and private sector expertise needed to assist homeowners in mitigation. At present, only a small number of specialized firms possess the capability to mitigate radon levels. Fulfillment of this goal would provide readily accessible assistance in mitigating the problem of indoor radon, in much the same way that water or electrical problems are now addressed. The Agency would fund initial projects to demonstrate control techniques and would establish a clearinghouse to disseminate this information to States and the private sector. Agency guidance on remediation would be issued to assure a consistent approach to such actions. Cooperative projects with the private sector would be encouraged to demonstrate and validate the effectiveness of mitigation techniques developed by the Agency projects. Until this goal is realized, CERCLA could be used on a limited basis to remediate situations which constitute environmental emergencies.

C: Promote Private Sector Development of Mitigation Techniques

This alternative goal relies on the private sector to develop mitigation techniques. As more homeowners discover elevated radon concentrations in their homes, a market for remedial services and materials will develop. The Agency would actively provide technical

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guidance to the private sector's effort to develop and supply mitigation measures to homeowners. Although no new mitigation projects would be funded, the Agency would promote cooperative projects with interested industries, provide quality assurance assistance, and work to disseminate results to States, homeowners, and the various components of private industry. States and industry groups would have the responsibility of ensuring a consistent application of remedial methods.

Selected Goal: Alternative B - Develop Mitigation Capability in States and the Private Sector Through Technology Transfer

This alternative goal is recommended because it offers a balance between the Federal government and the States and private sector responsibilities. Federal funding of initial demonstration projects stimulates similar work in the States and private sector as homeowners demand grows for mitigation methods; this has been the case in Pennsylvania. With this initial funding, we can also assure that effective techniques are available to remediate those homes which have known problems. Through Agency guidance on remediation techniques, we can establish a type of performance criteria that future techniques will have to meet.

Current efforts in this area are limited to the Agency's demonstrations of the performance of low-cost techniques for mitigating radon entry from soil. Low-cost techniques will be installed in 50 to 60 homes with various substructures at three locations in the United States. The first location is Boyertown, PA, where installations are being made in 18 homes. This work will demonstrate the performance and cost of several mitigation techniques in homes with moderate to high indoor radon levels from naturally-occurring radon. Other work has been previously done by the Superfund office to remediate homes with man-made contamination, such as in New Jersey.

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Issue 3: How Can Elevated Radon Levels in New Structures be Prevented?

- How can preventive techniques best be incorporated in new construction?
- What should be the Federal role in developing preventive techniques?
- How can the problem of construction on high risk lands best be addressed?

Alternative Goals

A: Implement a Federal Program to Prevent Radon Entry in New Structures

This alternative goal emphasizes Agency leadership in a national effort to designate high risk lands, develop effective preventive techniques, and incorporate these techniques in common construction practices. The Agency would designate potentially high risk lands based on the results of a national assessment and develop model building codes for adoption by local communities. The Agency would fund projects to develop and demonstrate preventive techniques. The Agency would promote a consistent approach to preventing radon entry in structures by serving as a national clearinghouse for the results of technology development.

B: Provide States With Technical and Policy Guidance on Preventive Techniques

This alternative goal focuses on providing the States with the necessary technical and policy guidance to limit radon entry in new structures. The Agency would provide States with the information and tools needed to identify high risk areas, but would not undertake such an effort itself. The Agency would initiate some Federally-funded projects to demonstrate preventive techniques, but the private sector would ultimately be expected to assume this responsibility. The Agency would then serve as a central clearinghouse for information on such activities. The Agency would also develop model building codes cooperatively with States and industry groups and would issue recommendations on effective construction techniques.

C: Promote Private Sector Development of Preventive Techniques

The intent of this alternative is to facilitate the private sector's efforts to supply consumer demand for radon-resistant housing. Results from remedial action on existing houses would be compiled to identify possible techniques for new construction, but demonstration projects would not be undertaken by the Agency. Information from States and builders on the success of new construction practices would similarly be compiled and disseminated to interested parties. A program to review and comment on building codes would be established.

Recommended Goal: Alternative B - Provide States with Technical and Policy Guidance on Preventive Techniques

As in the previous issue, selection of alternative B in this instance also provides a balance between the Federal government and the States and

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private sector responsibilities. The Agency would fund some initial projects to demonstrate preventive techniques; these projects are intended to serve as a springboard for the private sector. This is an area in which the States should take the lead role, with the Federal government providing technical guidance and assistance. Through the development of model building codes, the Agency can offer States and local governments a basis for developing policies to control radon entry into structures built on potentially hazardous lands.

At present, the Agency has had extremely limited involvement in this area. Work has been primarily focused on providing technical guidance to the State of Florida and HUD on preventive construction designs for use in structures built on the State's phosphate lands.

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Issue 4: How Should Program Direction and Leadership be Provided?

- How strong a role should EPA adopt in addressing the indoor radon problem?
- What responsibilities should be left to the States?
- Is a national program needed?

Alternative Goals

A: Establish a National Policy for Reducing Current and Future Indoor Radon Exposure

This alternative provides for a directed Federal program to effectively reduce both current and future exposures to indoor radon. Inherent in this goal is the belief that the Federal government has a strong responsibility and active role to play in addressing this environmental problem. Within the context of existing statutes, the Agency would develop Federal guidance on limiting public exposure to indoor radon. By aggressively developing a working relationship with States, this guidance could be incorporated into State policies to create a nationwide policy. In addition, training of State personnel, Federal responses to significantly elevated exposure conditions, and development of construction guidelines are examples of tasks that should be conducted on a nationwide basis under the aegis of the EPA. Strong Federal leadership would serve to stimulate States and the private sector to focus on this issue and would help to accelerate efforts to reduce population exposures.

B: Develop Guidance and Recommendations For States to Implement

This alternative allows the Agency to advise individual States on a case-by-case basis on programs to reduce exposures to indoor radon. EPA recommendations for action levels in existing housing and target levels for new housing would be prepared in a manner similar to those provided to the Governor of Florida in 1979 concerning exposures on phosphate lands. An aggressive training program for States' radiological staff would be pursued to assure their capabilities in dealing with the issue. The Agency would provide a continued program of assistance and technical guidance. A strong three-way bond among the Agency, States and the private sector would be developed to focus efforts to reduce exposure to indoor radon.

C: Assist State-Directed Programs

This alternative relies on the States to take the lead in addressing the indoor radon problem and is based on the premise that elevated radon levels in structures is a localized problem. EPA would provide technical advice on measurement techniques and protocols, mitigation measures, prevention programs, etc. The Agency would also provide policy guidance to State radon programs as requested.

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Selected Goal: Alternative A - Establish a National Policy for Reducing Current and Future Indoor Radon Exposure

This alternative is recommended because it provides for the development of a national indoor radon program. Existing survey data suggest that elevated levels of indoor radon is not a regionalized problem. Instead, instances of increased concentrations of this pollutant have been found in homes in nearly every area of the country. Because of its ubiquitous nature, a national program would best be able to assure a consistent approach to risk reduction among the States. This alternative goal incorporates this concept, but also allows for the transfer of knowledge and provision of policy guidance to the States.

In addition, several Federal agencies have programs which involve the problem of radon in structures. Federal utilities, such as the Bonneville Power Administration and the Tennessee Valley Authority, have implemented weatherization programs to tighten up homes which they serve. Such action might contribute to increased radon exposure in those homes. Similarly, the Department of Housing and Urban Development is mandated by statute to ensure that all HUD assisted projects are located in safe and healthful environments. This includes not only public buildings, but also individual homes. HUD has disapproved, in several cases, VA and FHA loans to potential buyers of houses with elevated radon levels. Because of these and other Federal programs, a need exists for guidance applicable to the Federal agencies on managing the problem of radon in structures.

At present, there is no national indoor radon program. Advice is given on a State-by State basis as requested and as permitted by limited EPA resources.

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V. Indoor Radon Program (Phase II: Implementation Plan)

We have chosen to illustrate one possible implementation scheme by selecting a "strawman" strategy consisting of the following alternative goals for each issue:

Issue 1	A:	Determine the National Exposure Distribution and Identify High Risk Areas
Issue 2	B:	Develop Mitigation Capability in States and the Private Sector
Issue 3	B:	Provide States with Guidance on Preventive Techniques
Issue 4	A:	Establish a National Policy for Reducing Current and Future Indoor Radon Exposure

In general, the choice of these goals is based on a recognized need to fully characterize the nature and extent of the indoor radon problem and to have the Agency adopt a strong role in establishing a cooperative risk reduction program with the States and the private sector. No direct regulatory program is envisioned. The selection of alternative A to address Issue 1 allows the Agency to mount an aggressive and extensive measurement program to identify not only high risk areas of the country, but also to determine the national distribution and average radon concentration in homes. This information is essential to determine the magnitude of the health risks associated with indoor radon exposure, as well as to determine the effectiveness of mitigation and prevention programs on reducing exposure. Selection of alternative B to address both Issues 2 and 3 represents a coordinated effort among the Federal government, state governments and the private sector to develop and inform homeowners on cost-effective mitigation techniques and preventive construction practices. This alternative calls for initial Federal support, but clearly intends for the ultimate responsibility to be assumed by the States and the private sector, as consumer demand for these methods increase. Finally, selecting alternative A to address Issue 4 calls for a strong Federal role in dealing with indoor radon problems by issuing Federal guidance and recommendations on limiting public radon exposure, thus encouraging a consistent national policy.

To realize the goals adopted in the recommended strategy, the Agency's information base must be expanded. Additional information is needed to better define the distribution of indoor radon levels in structures across the country, as well as to identify those areas of the United States in which elevated indoor radon concentrations may be a problem. A corollary need is to determine and characterize the factors which influence those levels. To respond to individual homeowner concerns, we should improve existing measurement techniques and protocols to facilitate their use by the average person. Finally, we need to develop and validate effective, inexpensive techniques to reduce radon concentrations in existing structures and to keep concentrations low in new structures.

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These information needs must be examined in the context of characterizing and remediating already discovered instances of elevated radon levels in homes, particularly in Boyertown, Pennsylvania. With this focus, the following immediate, short-term and long-term objectives were identified:

- o Immediate Objectives (within six months):
  - Coordinate current Federal involvement in Pennsylvania
  - Coordinate Federal response to Congressman Ritter's request for information on indoor radon
  - Determine emergency criteria for applying CERCLA funds to naturally-occurring events
  - Remediate those areas which present an environmental emergency
- o Short-term Objectives (six-twelve months):
  - Identify the potential for high-risk areas
  - Disseminate existing information to the public on risk, control techniques, etc.
  - Enhance measurement capabilities in States
  - Encourage private sector development of mitigation methods
- o Long-term objectives (beyond one year):
  - Provide criteria for determining high risk lands
  - Demonstrate low-cost mitigation methods
  - Expand measurement capabilities of States
  - Provide health guidelines
  - Inform public and industry on measurement techniques, mitigation methods, and preventive construction techniques
  - Define distribution of risks in the United States

Following is a five year plan which lays out major tasks necessary to meet the aforementioned objectives and identifies which EPA office should have the lead.

Year 1 30.3 FTE $3,200,000 Extramural Funds

- o Publish existing information on determining high risk lands (ORP)
- o Provide interim health guidelines and Superfund emergency criteria (ORP, OSWER)
- o Publish existing information on control techniques (ORP, ORD)
- o Continue to assist State measurement efforts (ORP)
- o Publish measurement protocols (ORP)
- o Continue State training programs (ORP, OEI)
- o Initiate cooperative projects with industry (ORP, ORD)
- o Complete design of data handling system for national assessment (ORP, ORD)
- o Complete design of national assessment (ORP, ORD)
- o Continue to demonstrate low-cost remedial techniques for existing housing (ORD)
- o Initiate development of low-cost measurement techniques (ORP, ORD)
- o Initiate research on preventive construction practices (ORD)

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- Initiate epidemiological studies (ORD)
- Continue evaluation of Agency information dissemination program (OPPE)
- Conduct remedial actions in known problem areas (ORP, OSWER)
- Initiate evaluation of cost-effectiveness of various control program options (OPPE)
- Evaluate existing State and local radon programs and interests (OPPE)
- Propose standard for radon in drinking water (ODW)

Year 2 30.3 FTE $2,975,000 Extramural Funds

- Initiate national assessment (ORP)
- Continue development of new mitigation methods (ORD)
- Continue research on preventive construction practices (ORD)
- Continue State training programs (ORP, OEI)
- Continue development of low-cost measurement techniques (ORP, ORD))
- Continue cooperative projects with industry (ORP, ORD)
- Continue epidemiological studies (ORD)
- Continue evaluation of Agency information dissemination program (OPPE)
- Initiate development of radon calibration standards (ORD)
- Distribute public information and education materials on radon (ORP, OEI, OEA)
- Continue evaluation of cost-effectiveness of various control program options (OPPE)
- Promulgate standard for radon in drinking water (ODW)

Year 3 27.3 FTE $2,250,000 Extramural Funds

- Complete measurement component of national assessment (ORP)
- Initiate source characterization of areas with elevated levels (ORP)
- Initiate statistical analysis of data from national assessment (ORP)
- Conduct field validation of mitigation methods (ORP)
- Conduct field validation of preventive construction practices (ORP)
- Initiate development of model building codes (ORP, ORD))
- Complete State training programs (ORP, OEI)
- Continue epidemiological studies (ORD)
- Continue development of radon calibration standards (ORD)
- Complete evaluation of Agency information dissemination program (OPPE)
- Complete development of low-cost measurement techniques (ORP)
- Verify long-term effectiveness of mitigation methods in demonstration homes (ORD)
- Initiate development of Federal guidance and recommendations (ORP)
- Initiate development of implementation handbook (ORP)
- Prepare progress report to the Administrator (ORP, ORD)
- Continue cooperative projects with industry (ORP, ORD)
- Complete evaluation of cost-effectiveness of various control program options (OPPE)
- Implement radon drinking water standard (ODW)

Year 4 21.8 FTE $1,450,000 Extramural Funds

- Complete field validation of mitigation and preventive construction practices (ORP)

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- o Complete statistical analyses of data from national assessment (ORP)
- o Complete model building codes and initiate outside review (ORP, ORD)
- o Continue epidemiological studies (ORD)
- o Continue development of radon calibration standards (ORD)
- o Publish criteria for determining high risk lands (ORP)
- o Continue cooperative projects with industry (ORP, ORD)
- o Propose Federal guidance and recommendations (ORP)
- o Implement radon drinking water standard (ODW)

Year 5 — 16.8 FTE — $900,000 Extramural Funds

- o Issue Federal guidance and recommendations (ORP)
- o Publish implementation handbook for public and private sector (ORP)
- o Continue epidemiological studies (ORD)
- o Complete development of radon calibration standards (ORD)
- o Continue cooperative projects with industry (ORP, ORD)
- o Implement radon drinking water standard (ODW)

In identifying project goals, information needs, and specific tasks, consideration was given to the need for interagency coordination. Other Federal agencies, particularly DOE, have expertise and responsibilities in this area. EPA would work to coordinate its program with the other Federal agencies to ensure that our respective efforts are complementary and avoid duplication and gaps. This would include close coordination on budget and program plans.

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VI. Management Plan

Because of the multi-dimensional nature of the indoor radon issue, any Agency strategy to address this problem must involve a cross section of EPA program offices. Current involvement by several of these interested offices was identified previously; this section discusses in a more general sense the appropriate role and direction of the major Agency programs which will contribute to an integrated and coordinated solution to the problem of indoor radon, the necessary resource commitments, and the environmental benefits to be derived.

PROGRAM RESPONSIBILITIES

Office of Radiation Programs: Over the past ten years, ORP has developed recognized expertise in radiation risk assessment, measurement development, and hazard evaluation. It has provided extensive technical assistance to States and other Federal agencies in remediating areas of elevated radon concentration in structures. Because of its varied experiences, ORP will provide the central focus for the management of an integrated Agency strategy to reduce current and future exposures to indoor radon. This role could include such tasks as continued provision of technical assistance to States, conduct of exposure assessment programs, development of Federal guidance under the Atomic Energy Act authority, field validation of mitigation measures and preventive construction techniques, and issuance of guidelines to homeowners and the building industry on mitigative and preventive construction practices.

Office of Research and Development: In the last two years, ORD has sponsored research on various aspects of the indoor radon issue, including mitigation methods and land characterization. In addition, ORD is evaluating proposals to conduct several epidemiological studies to determine the relationship between elevated indoor concentrations of radon and premature development of fatal cancers. In an integrated Agency plan, ORD will continue to take the lead in researching, developing, and demonstrating mitigation methods and preventive construction techniques. The Office will also develop radon calibration standards, provide overall quality assurance support, and conduct epidemiological studies, where appropriate.

Office of Policy, Planning, and Evaluation: OPPE is now evaluating the cost-effectiveness of various remedial program options. Under the recommended strategy, this work will continue and will be enhanced by the development of actual cost figures and improved risk estimates. Additionally, this program office will have the lead in determining the individual homeowner's response to Agency information on risk, mitigation costs, etc. This research can be used to shape an effective and responsive information dissemination program.

Office of Solid Waste and Emergency Response: As the program office which administers CERCLA, OSWER will have a continuing role in responding to environmental emergencies involving elevated indoor radon levels. Information collected and remediation activities sponsored by Superfund

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monies will be shared with other program offices and the public, as appropriate. OSWER will also work with other program office to develop and implement health criteria for remedial actions. Legislative initiatives promoted by the Agency to address Federal funding of emergency clean up of contaminated sites using CERCLA will likely be focused in this Office.

Office of Drinking Water: ODW is currently developing standards to limit the amounts of both radium and radon in drinking water. This effort is important to the overall Agency strategy since it will provide a regulatory cap on one source of indoor radon exposure. In addition to developing and implementing these standards, ODW will have responsibility for disseminating information on radon in drinking water to States and interested homeowners.

Office of General Counsel: OGC will serve as the legal advisor to all program office as they begin to implement their piece of the Agency plan. Specific activities might include working with ORP to develop Federal guidance, advising OSWER on the legal implications of applying Superfund in certain situations, etc. New legislative initiatives for Federal funding, such as tax credits or low-interest loans, would be developed jointly with OGC.

Office of External Affairs: OEA will work with the various program offices to develop public information documents, legislative initiatives, responses to Congressional inquiries, etc.

Outreach and Economic Incentives Staff: OEI will assist ORP in providing a link to the public through various organizations which have an interest in indoor air. In addition, OEI will develop an outreach program on radon to disseminate needed information.

The above discussion should provide a perspective of the appropriate roles and responsibilities for interested EPA offices. As the plan is implemented, other EPA offices may be called upon to assist in various aspects of the plan. Specific task assignments were indicated in the previous section for the "strawman" strategy. Assignment of tasks based on a different combination of goals and objectives would follow the broad policy lines discussed above.

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RESOURCE REQUIREMENTS

Resource requirements for the "strawman" strategy are estimated below:

		FTE	Ex$ (000)	In$* (000)
Year 1	ORP	22.0	2,000	250
	ORD	6.0	950	40
	OSWER	1.0	Unknown	--
	OPPE	0.3	200	--
	OEI	1.0	50	--
	Total	30.3	3,200	290
Year 2	ORP	23.0	1,675	250
	ORD	6.0	1,050	110
	OPPE	0.3	200	--
	OEI	1.0	50	--
	Total	30.3	2,975	360
Year 3	ORP	20.0	1,400	200
	ORD	6.0	600	60
	OPPE	0.3	200	--
	OEI	1.0	50	--
	Total	27.3	2,250	260
Year 4	ORP	15.0	700	200
	ORD	6.0	550	40
	OPPE	0.3	200	--
	OEI	0.5	----	--
	Total	21.8	1,450	240
Year 5	ORP	12.0	500	150
	ORD	4.0	200	20
	OPPE	0.3	200	--
	OEI	0.5	----	--
	Total	16.8	900	170

* Includes travel and equipment needs only

Although these resource requirements were projected only for a five year period, one can expect that some level of resource commitment will be necessary beyond that period for continued provision of technical assistance, implementation of Federal guidance, conduct of epidemiological studies, etc. No attempt was made to estimate this "maintenance" program, since it is so highly dependent on the results of the first five years' efforts.

Although resource requirements were not developed for all of the possible combinations of alternative goals, boundary costs were estimated. Selecting alternative A for each issue represents the most

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costly combination of goals, and would increase the resource requirements each year by approximately 30 percent. Selecting alternative C for each issue represents the least costly goal combination and would decrease the projected yearly resource requirements by about 50 percent. For further clarification, we have outlined below the total five year resource investment for the two boundary strategies and the "strawman" strategy:

Goal Combination	FTE	EXS (000)	INS (000)
AAAA	164.5	14,010	1,720
ABBA (recommended)	126.5	10,775	1,320
CCCC	63.3	5,400	660

ENVIRONMENTAL BENEFITS

Quantification of the environmental benefits to be realized by implementation of this project plan is somewhat difficult. Because the extent of the indoor radon problem in this country has not been fully characterized, estimations of the quantity of risk reduction achieved by the plan are somewhat limited. However, we estimate the amount of risk reduction achievable by the "strawman" strategy to be approximately 35 - 50 percent. Similarly, risk reduction achievable by a more resource intensive program would be greater than 50 percent perhaps as high as 60-75 percent; by a less resource intensive program, less than 35 percent, perhaps as low as 5-20 percent.

This estimated risk reduction will be achieved in several ways. As a result of analyzing and adopting various construction practices and energy conservation methods, specific guidance on techniques to prevent the infiltration of radon gas into newly-built structures can be developed. Acceptance of this guidance into construction practices is likely to decrease the average level of radon in new U.S. homes.

Similarly, by reducing the levels in existing structures through the application of inexpensive mitigation techniques, the national average exposure may actually be reduced. Ultimately, the number of lung cancers caused by exposure to radon in structures would decline significantly. The more widespread the use of control methods and preventive techniques, the greater the reduction in health risks.

An underlying benefit in implementing this plan is the easement of the growing public concern about the hazards of indoor radon. It is necessary to convince the public that while radon presents a significant health risk, it is not an insurmountable problem. A major objective of the proposed program is to demonstrate that measures that will reduce elevated indoor radon levels by at least 90% can be installed for a few hundred dollars per structure. This would put the problem on the same economic scale as installing a sump pump in one's basement to correct a water problem. This plan would give an individual homeowner the necessary information to measure the radon concentrations in his home, determine what the levels mean in terms of health risk, and select from a range of low-cost mitigation methods.

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INTRAAGENCY COORDINATION AND MANAGEMENT

The management of the Agency's strategy for addressing the problem of indoor radon must take place on two levels. Policy decisions and program direction must be provided by the senior management of the Agency. Information collection and presentation to feed these decisions is the responsibility of the Agency's middle management component. Therefore, it would be useful to form both an advisory group at the Assistant Administrator level and an intraagency work group among representatives of the involved program offices. These groups would guide and monitor the implementation of the program within EPA and recommend modifications as appropriate in the future.

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VII. Intergovernmental Coordination

There is active interest on the part of other Federal agencies to evaluate the problem of elevated radon concentrations in homes. The Department of Energy and the Department of Housing and Urban Development have particular interest in the effects of radon in the indoor environment. DOE's energy conservation activities are balanced with efforts to assess and mitigate the effect of conservation on indoor radon levels. HUD is mandated by statute to ensure that all HUD-assisted projects are located in safe and healthful environments. In this context, HUD is interested in developing inexpensive and effective mitigation techniques for new and existing houses.

These concerns have led to the formation of several forums for the discussion of the indoor radon problem by interested Federal agencies. The Committee on Indoor Air Quality, which is comprised of 16 Federal agencies, has a special workgroup to develop a coordinated Federal response to this problem. EPA and DOE co-chair this group which has prepared a document outlining the indoor radon issue, assessing current Federal research efforts, and identifying priority information needs. These priority tasks are consistent with those identified in this document.

In addition, the Committee on Interagency Radiation Research and Policy Coordination (CIRRPC), under the Office of Science and Technology Policy (OSTP), is examining the radon issue through its Radon Subpanel which is currently reviewing the scientific knowledge on radon. CIRRPC consists of representatives from eighteen Federal agencies and a subcabinet level representative from the OSTP, and has responsibility to coordinate radiation matters among Federal agencies, evaluate radiation research, and advise the OSTP on issues of radiation policy. Refinement of the Agency's strategy and management plan will be coordinated with CIRRPC through EPA's representative on the Radon Subpanel.

Finally, a mechanism exists for integrating a Federal policy with State programs. The Conference of Radiation Control Program Directors, which is composed of representatives from all fifty States, has been working with EPA staff to ensure that State interests are adequately reflected in a Federal indoor radon program. This group will be particularly useful in implementing a national program to provide information, training, and technical advice to individual States.

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HEALTH RISKS DUE TO RADON IN STRUCTURES

A Strategy and Management Plan for Assessment and Mitigation

U.S. Environmental Protection Agency

September 1985

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I. Introduction

Recently, the problem of high indoor concentrations of radon and its decay products has received growing public and Congressional attention. Discovery of extremely elevated levels of this indoor air pollutant in homes in the Boyertown, Pennsylvania, area has highlighted the need for a coordinated Federal and State approach to reducing the risk of this significant health hazard. The Environmental Protection Agency (EPA) has developed a strategy to assess and mitigate the health risks due to radon in structures. The strategy builds upon existing knowledge and focuses not only on reducing significant current risks, but also on reversing trends in structure design, siting, construction, and maintenance that could increase risks in the future.

II. Review of the Problem

Radon, a naturally-occurring radioactive gas, is generally recognized as a key pollutant in the indoor environment. Radon is produced from the radioactive decay of radium-226, which occurs naturally in almost all soils and rocks. While the concentration of radon in the outdoor environment does not usually pose a significant health hazard, the indoor concentration can be several thousand times higher than outdoors.

The rate of entry of radon into a structure and the air exchange rate influence the indoor radon concentration. Radon will concentrate in indoor environments because of the limited exchange rate between indoor and outdoor air. In many buildings, the most significant pathway of radon entry is migration from soil into the structure through the basement or foundation. The rate of radon entry is affected by many factors, including radium content of the soil near a structure, soil moisture and porosity, and structure type. The variability of all these factors contributes to the wide distribution of radon concentrations that have been observed in homes in the United States.

The hazards posed by increased levels of radon arise primarily from two of its short-lived radioactive decay products, polonium-218 and polonium-214. These decay products tend to adhere to dust particles or other surfaces. If inhaled, the decay products deposit in the lungs, where they undergo further radioactive decay thus exposing the surrounding tissue to alpha radiation. Such radiation exposure can lead to lung cancer.

Estimates of the risk associated with exposure to radon decay products are based on several epidemiological studies of underground miners. A very high incidence of lung cancer attributable to exposure to radon decay products has been well-documented in studies conducted in a

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number of countries. Mortality and exposure data have been used to calculate risk coefficients for a unit exposure to radon decay products. Concentrations of radon decay products are measured in working levels (WL)*. Cumulative exposure to the decay products is measured in terms of working level months (WLM).

Current estimates suggest that the risk of lung cancer is doubled by a cumulative exposure of 20-100 working level months. (The average national lung cancer risk is about 3 in 100.) Statistically significant increased risk of lung cancer in miners is observed for exposures as low as 80 WLM. In homes, however, measured exposure rates can range from 0.02 WLM per year to over 200 WLM per year. Lifetime exposures at these rates lead to cumulative exposures ranging from about 1 WLM to over 10,000 WLM. Thus, a person's lifetime risk of lung cancer could be increased to well over one chance in two.

Several radiation protection groups have estimated the number of annual lung cancer deaths attributable to indoor radon. Since we do not know the true distribution of exposures, these estimates are based on lifetime exposure (at 75% occupancy) to the average indoor level of radon decay products (estimated to be about 0.004 WL), the number of dwellings and residents in the United States, and values for lung cancer risk coefficients. The resulting estimate of aggregate health effects over all exposure levels ranges from about 5,000 to 20,000 lung cancer deaths per year. The difference between the upper and lower values is primarily associated with the use of different unit risk coefficients by various investigators. The current U.S. mortality rate from lung cancer is about 120,000 deaths per year. Improvement in the health risk estimates depends largely on obtaining better data on the national distribution of indoor radon levels. Figure 1 illustrates the likely general shape of the distribution of indoor radon decay product levels. The dotted line in Figure 1 indicates a shift of the distribution curve to the right which is a likely result of current building practices which may lower ventilation rates. This hypothetical curve, derived from the limited available data, demonstrates that exposure to radon decay products is likely to be associated with very large individual and total population risks in the United States.

III. Current Agency Status on Indoor Radon

Over the past 15 years, the Agency has developed a range of expertise and interests in various aspects of the indoor radon issue. Many activities resulted from programs to assist States with specific problems of elevated indoor radon levels, in areas such as Colorado, Pennsylvania, New Jersey and Florida. Other work was performed to support rulemakings under the Clean Air Act, Uranium Mill Tailings Radiation Control Act, and

* A working level is defined as any combination of the short half life radon decay products which ultimately emits 1.3×10^5 million electron volts of alpha-ray energy in one liter of air.

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WHAT IS THE NATIONAL DISTRIBUTION OF RADON EXPOSURE?

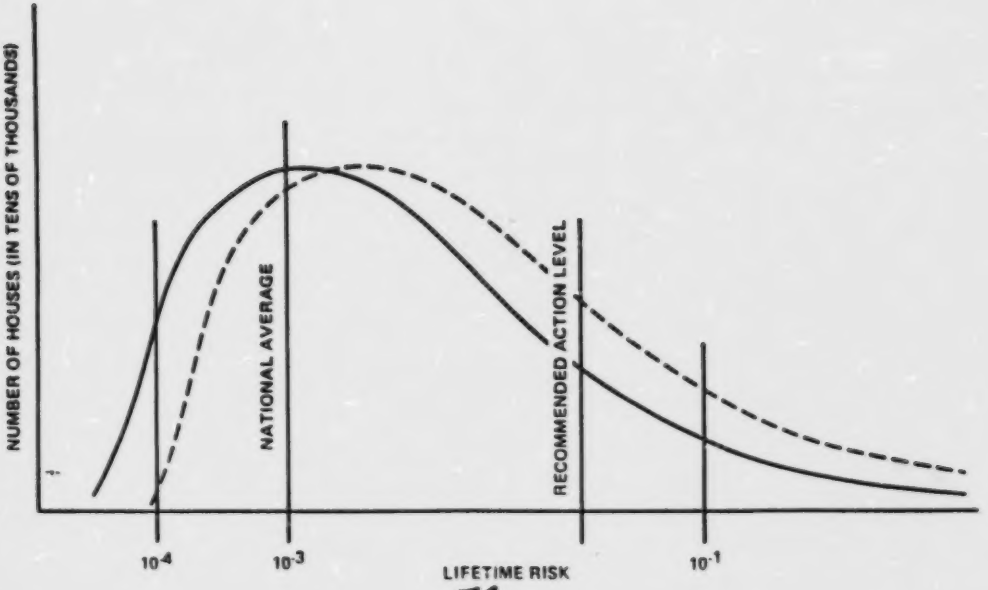

Figure 1

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Safe Drinking Water Act. More recently, the Agency has begun a few projects on indoor radon with a portion of the funds provided by Congress in FY 1984 and FY 1985 for work on indoor air quality. Major areas of the Agency's past and current efforts are briefly described below.

Assistance to States: Starting in the early 1970's, EPA has responded to States' requests for technical assistance to investigate indoor radon exposure due to uranium mill tailings, phosphate ores and wastes, radium wastes, and natural sources. This assistance has included technical guidance, remediation projects, and measurement programs.

Mitigation Methods: In response to the need to demonstrate control techniques and provide short-term mitigation of elevated levels, the Agency has evaluated both preventive construction techniques for new structures and remedial methods for contaminated structures. This latter activity has examined both man-made and naturally-occurring sources of contamination.

Health Effects: In support of EPA rulemaking activities, the Agency has invested a great deal of effort in estimating the risks of cancer associated with exposure to radon. Past Agency funding for epidemiology and radiation dosimetry have contributed greatly to the current state of the art in risk assessment.

Measurement Methods: The measurement of radon and its decay products has long been an area of EPA involvement. Several important measurement methods that are currently in use were developed primarily with EPA support and guidance.

Policy Development: The development of policy perspectives and risk management programs have been another area of EPA involvement. The promulgation of standards for the cleanup of uranium mill tailings and the preparation of recommendations to the Governor of Florida were major exercises in this area. More recently, EPA has worked with the Centers for Disease Control to prepare criteria for removal activities under Superfund.

Superfund Actions: Remediation or removal actions involving indoor radon exposure have been conducted at several sites under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). In all cases, the CERCLA response was initiated due to radium contamination resulting from man's activities. CERCLA has not been used to remediate situations of contamination from naturally-occurring sources.

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IV. The Strategy

The primary objective of the Agency's efforts to address the indoor radon problem is to reduce human exposure and risk by both reducing significant current risks and reversing trends in structure design, siting, construction, and maintenance that could increase risks in the future. At present, the magnitude and scope of the indoor radon problem are not well understood, both nationally and regionally. Further, numerous data collection and technical development efforts are needed to provide cost-effective mitigation methods and policy tools. Nonetheless, existing evidence strongly indicates that the health risks from exposure to indoor radon are significant in several areas of the country, most notably the Reading Prong area of Pennsylvania and New Jersey. We have also acquired sufficient technical knowledge to help facilitate action by the public and the States to mitigate risks in these areas. Consequently, the Agency's strategy addresses four major aspects of the indoor radon problem, including: 1) exposure and risk assessment, 2) mitigation of exposure in existing structures, 3) prevention of exposure in future construction, and 4) program direction and leadership.

These issues were chosen to allow decisionmakers to focus on related, but separable, pieces of the problem. Unique considerations exist for each aspect, and an aggressive approach to one aspect may not be desired for another. The four issues are not intended to represent the only possibilities, but instead reflect a systematic way of examining the problem. Issue 1, exposure and risk assessment, addresses the need to determine the nature and extent of the problem and the associated risks. Issues 2 and 3, mitigation and prevention, deal with risk reduction. It is important to examine separately existing structures and new construction, since the technical and policy means of achieving risk reduction in these two instances is somewhat different. The fourth issue, program direction, relates to the question of the appropriate role for the Federal government to take in dealing with the problem of radon in structures.

The Agency is not proposing a direct regulatory program. Instead, the Agency's strategy is to work with the States and the private sector to characterize the problem of radon in structures and to develop inexpensive and reliable means to mitigate risks in existing buildings and to prevent risks in future construction. Following is a further discussion of each of the four issues previously described, including related topics of concern and the Agency's approach to addressing them.

Issue 1: What are the Exposures and Risks from Indoor Radon?

- What is the magnitude of exposure to radon in U.S. homes?
- What are the sources and their relative importance?
- What are the risks and how are they distributed?
- What are the national and regional exposure and risk trends?

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Approach: Determine the national exposure distribution and identify high risk areas.

This approach would provide a national perspective of the sources, levels, and estimated health effects associated with elevated concentrations of radon in structures. Existing information on indoor radon levels is based on a fragmentary set of results from surveys conducted by different groups in scattered locations across the United States. A nationwide assessment of the problem would be undertaken to better estimate individual and population exposures, to identify land and structure characteristics related to elevated radon levels, and to quantify the relative contributions to exposure from land, water, and building materials. In addition, simple and inexpensive measurement methods and protocols would be developed for use by the average homeowner.

Issue 2: How can Exposure to Radon in Existing Structures be Reduced?

- What role should the Federal government play in technology transfer?
- What is the appropriate Federal role in developing and demonstrating control technology?
- How much financial or technical assistance should be provided to homeowners?

Approach: Develop mitigation capability in States and the private sector.

The Agency's answer to the need to mitigate risks in existing structures is to actively develop State and private sector expertise to assist homeowners. At present, only a small number of specialized firms possess the capability to reduce radon levels in structures. This approach would ultimately provide to homeowners readily accessible assistance in mitigating the problem of indoor radon, in much the same way that water or electrical problems are now addressed. The Agency would initially sponsor the development and demonstration of inexpensive and reliable control techniques and would establish a clearinghouse to disseminate this information to States and the private sector. It is intended that the private sector eventually assume these functions.

Issue 3: How Can Elevated Radon Levels in New Structures Be Prevented?

- How can preventive techniques best be incorporated in new construction?
- What should be the Federal role in developing preventive techniques?
- How can the problem of construction on high risk lands best be addressed?

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Approach: Provide States with technical and policy guidance on preventive techniques.

Similar to its approach in mitigating risk in existing structures, the Agency's role in preventing risk in future construction is intended to provide initial direction to the States and the private sector. The Agency would sponsor some projects to demonstrate preventive techniques; these projects would serve as a springboard for the private sector. The Agency would also work with interested States to develop policies to control radon entry into structures built on potentially hazardous lands.

Issue 4: How Should Program Direction and Leadership Be Provided?

- How strong a role should EPA adopt in addressing the indoor radon problem?
- What responsibilities should be left to the States?
- Is a national program needed?

Approach: Initiate a national program to reduce current and future radon exposure in structures.

Without a coordinated Federal approach to solving this environmental problem, individuals across the country will continue to be faced with a significant health risk. Existing survey data suggest that elevated levels of indoor radon is not a regionalized problem. Instead, instances of increased concentrations of this pollutant have been found in homes in nearly every area of the country. Because of the ubiquitous nature of the indoor radon problem, a national program is necessary to avoid inconsistencies among State programs designed to address this issue. The Agency would work with other parts of the Federal government in providing advice and guidance to States and localities on ways in which to assess and mitigate exposure. Federal leadership, at this time, would serve to stimulate States and the private sector to focus on this issue and would help to accelerate efforts to reduce population exposures.

V. Implementation Plan

To realize the goals adopted in the strategy, the Agency's information base must be expanded. Additional information is needed to better define the distribution of indoor radon levels in structures across the country, as well as to identify those areas of the United States in which elevated indoor radon concentrations may be a problem. A corollary need is to determine and characterize the factors which influence those levels. To respond to individual homeowner concerns, we should improve existing measurement techniques and protocols to facilitate their use by the average person. Finally, we need to develop and validate effective, inexpensive techniques to reduce radon concentrations in existing structures and to keep concentrations low in new structures.

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These information needs must be examined in the context of characterizing and remediating already discovered instances of elevated radon levels in homes, particularly in Boyertown, Pennsylvania. With this focus, the following short-term and long-term objectives were identified:

- Short-term Objectives:
  - Identify preliminary criteria for high risk areas
  - Disseminate existing information on risk, control techniques, etc.
  - Improve measurement capabilities in States
  - Coordinate current Federal involvement in Pennsylvania
  - Provide response to Congressional requests for information on the problem of indoor radon

- Long-term objectives:
  - Provide criteria for determining high risk lands
  - Demonstrate low-cost mitigation methods
  - Expand measurement capabilities of States
  - Provide health guidelines
  - Inform public and industry of measurement techniques, mitigation methods, and preventive construction techniques
  - Define distribution of risks in the United States

These objectives can be met over the next five years through the execution of the following major tasks:

- Development of a model to predict the potential for structures built on certain land types to have elevated indoor radon concentrations.

- Conduct of a national assessment of representative structure types and geographical locations.

- Development of inexpensive and accurate measurement techniques and protocols.

- Demonstration of low-cost remedial and preventive construction techniques.

- Establishment of a Federal clearinghouse for information on assessing mitigating exposure to indoor radon.

- Conduct of State training programs on measurement techniques, risk evaluation, and remedial methods.

- Coordination of Federal efforts in addressing indoor radon.

- Issuance of technical guidance and advice to States in developing policies to mitigate indoor radon exposure.

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ENVIRONMENTAL BENEFITS

Quantification of the environmental benefits to be realized by implementation of this strategy is somewhat difficult. Because the extent of the indoor radon problem in this country has not been fully characterized, estimations of the quantity of risk reduction achieved by the plan are somewhat limited. However, we estimate the amount of risk reduction achievable by the strategy to be approximately 35 - 50 percent.

This estimated risk reduction will be accomplished in several ways. As a result of analyzing and adopting various construction practices and energy conservation methods, specific guidance on techniques to prevent the infiltration of radon gas into newly-built structures can be developed. Acceptance of this guidance into construction practices is likely to decrease the average level of radon in new U.S. homes.

Similarly, by reducing the levels in existing structures through the application of inexpensive mitigation techniques, the national average exposure may actually be reduced. Efforts to identify and remediate homes containing very elevated levels of radon would also serve to lower the very high individual risks of cancer on areas such as the Reading Prong. Ultimately, the number of lung cancers caused by exposure to radon in structures would decline significantly. The more widespread the use of control methods and preventive techniques, the greater the reduction in health risks.

An underlying benefit in implementing this plan is the easement of the growing public concern about the hazards of indoor radon. It is necessary to understand that while radon presents a significant health risk, it is not an insurmountable problem. A major objective of the strategy is to demonstrate that measures that will reduce elevated indoor radon levels by at least 90% can be installed for a few hundred dollars per structure. This would put the problem on the same economic scale as installing a sump pump in one's basement to correct a water problem. This plan would give an individual homeowner the necessary information to measure the radon concentrations in his home, determine what the levels mean in terms of health risk, and select from a range of low-cost mitigation methods.

VI. Intergovernmental Coordination

There is active interest on the part of other Federal agencies to evaluate the problem of elevated radon concentrations in homes. The Department of Energy and the Department of Housing and Urban Development have particular interest in the effects of radon in the indoor environment. DOE's energy conservation activities are balanced with efforts to assess and mitigate the effect of conservation on indoor radon levels. HUD is mandated by statute to ensure that all HUD-assisted projects are

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located in safe and healthful environments. In this context, HUD is interested in developing inexpensive and effective mitigation techniques for new and existing houses.

In identifying project goals, information needs, and specific tasks, consideration was given to the need for interagency coordination. Other Federal agencies, particularly DOE, have expertise and responsibilities in this area. EPA is currently coordinating its program with the other Federal agencies to ensure that our respective efforts are complementary and avoid duplication and gaps. This coordination would be particularly emphasized in implementing the above five-year plan, and discussions would include budget and program plans.

MECHANISMS FOR COORDINATION

These different agency concerns have led to the formation of several forums for the discussion of the indoor radon problem by interested Federal agencies. The Committee on Indoor Air Quality, which is comprised of 16 Federal agencies, has a special workgroup to develop a coordinated Federal response to this problem. EPA and DOE co-chair this group which has prepared a document outlining the indoor radon issue, assessing current Federal research efforts, and identifying priority information needs. These priority tasks are consistent with those identified in this document.

In addition, the Committee on Interagency Radiation Research and Policy Coordination (CIRRPC), under the Office of Science and Technology Policy (OSTP), is examining the radon issue through its Radon Subpanel which is currently reviewing the scientific knowledge on radon. CIRRPC consists of representatives from eighteen Federal agencies and a subcabinet level representative from the OSTP, and has responsibility to coordinate radiation matters among Federal agencies, evaluate radiation research, and advise the OSTP on issues of radiation policy. Refinement of the Agency's strategy and management plan will be coordinated with CIRRPC through EPA's representative on the Radon Subpanel.

Finally, a mechanism exists for integrating a Federal policy with State programs. The Conference of Radiation Control Program Directors, which is composed of representatives from all fifty States, has been working with EPA staff to ensure that State interests are adequately reflected in a Federal indoor radon program. This group will be particularly useful in implementing a national program to provide information, training, and technical advice to individual States.

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CURRENT ACTIVITIES

There is currently a high degree of coordination among the various Federal and State activities on indoor radon. While much of this coordination was initially motivated by the desire to avoid duplication of research, recent activities have focused on producing improved results by using the resources and expertise of different agencies, offices and States. In particular, EPA and DOE are succeeding in efforts to jointly support projects, actively share new information, plan and assign priorities for new projects, and to prepare consistent and complete responses to requests for information. Other groups, such as HUD, the U.S. Geological Survey, the National Bureau of Standards, the Centers for Disease Control, and several States are also active in several interagency efforts on indoor radon. Specific activities that reflect this intergovernmental coordination are:

- Demonstration of radon preventive construction techniques: EPA, HUD, and the State of Florida are jointly assisting a major land developer in a project to design and construct homes that prevent radon entry on Florida phosphate lands. This effort is intended to provide builders with some guidance on techniques for possible use in complying with standards on indoor radon recently published by the State of Florida.

Coordination of Federal activities in Pennsylvania: EPA, DOE, and HUD are continuing to coordinate Federal assistance to the State of Pennsylvania. In July, representatives from DOE and EPA met with the State's radiological staff to review current assistance efforts, technical and policy information needs, and planned research activities in the State. A major future research activity is the conduct of a DOE-funded epidemiology project in Pennsylvania. EPA is assisting DOE in reviewing the design of this study and is exploring the potential for combining the project with EPA-funded epidemiology efforts.

Planning of objectives for a national assessment: Several radiation protection groups and proposed Congressional bills have called for a national assessment of indoor radon levels. Several preliminary tasks are necessary to support such an effort; these include the selection of specific objectives for the assessment, identification of the sample population to be monitored, and choice of monitoring methods. To coordinate an examination of the preliminary tasks, the EPA Office of Radiation Programs has invited a group of experienced workers in the radon field to a workshop to be held in September, 1985. Participants include representatives from the DOE, HUD, USGS, the State Conference of Radiation Control Program Directors, and the National Council on Radiation Protection.

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Characterization of hazard potential of lands: The DOE and EPA are working to combine their interests and resources in projects to develop methods for determining the potential of lands to cause elevated radon in homes built upon them.

An increase in the quality and amount of intergovernmental coordination would be expected to follow the implementation of an EPA program on indoor radon. Presently, efforts to coordinate activities are hindered by the absence of overall objectives. Clarification of the Agency's position on the indoor radon issue, as represented by this document, will prompt and assist other groups in identifying tasks that they feel to be important, as well as the roles that they will play in completing those tasks.

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Mr. SCHEUER. It is so ordered.

We order that the full testimony of both witnesses be printed at the appropriate place in the record.

I want to thank you, Senator, for your forthright and hard-hitting testimony. We, too, believe that the OMB is the culprit. We, too, believe that the EPA would like to do the job that is their mission, and that they have been crippled and hampered and roadblocked by the OMB.

The two of you have provided outstanding leadership on this issue together, and we again thank the two of you.

Now, Senator Mitchell, please let us have your statement.

STATEMENT OF HON. GEORGE J. MITCHELL, A U.S. SENATOR FROM THE STATE OF MAINE

Senator MITCHELL. Thank you very much, Mr. Chairman.

Since you have indicated that our full statements will be placed in the record, I will attempt to briefly summarize them and not be repetitious of the points that have already been well made by Senator Lautenberg.

I thank you for the opportunity to be here today to testify on the importance of human exposure to radon gas. I am pleased to be here with my colleague, Senator Lautenberg. As he indicated, we have worked together to develop legislation to address radon and other indoor problems, and I commend Senator Lautenberg for his effort and leadership in this area.

The fact that exposure to radon and other indoor air pollutants is a serious threat to public health is well known. I will comment only in addition that in my home State of Maine, a State which is not high in population by national standards, there is evidence that some 75 people die each year of lung cancer caused by exposure to radon.

I would like to make a brief comment on the EPA material that Senator Lautenberg referred to. But first, it should be recognized that this is a reversal of position by the EPA. Just this spring, EPA called radon a low budget priority and discontinued any funding.

Second, while EPA has drafted a program, the administration has not yet agreed to fund it. Third, the EPA strategy does not contain the specific research activities or control programs needed to substantially reduce present risks.

There is a better approach to this problem. On September 18, the Senate adopted legislation sponsored by Senator Lautenberg and I which directs the EPA to conduct a comprehensive program of research into radon and other indoor pollutants. The legislation, called the Indoor Air Quality Research Act of 1985, was, as you well know, Mr. Chairman, originally drafted by you and Mrs. Schneider and introduced in the House as H.R. 2101.

The legislation as finally adopted by the Senate includes several changes in that original draft which more specifically address radon. For example, we added a requirement that EPA provide a report in 1 year identifying areas with high radon levels and providing public information materials concerning measures to reduce radon in private homes.

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These changes were developed as a result of a field hearing by the Environment and Public Works Committee, which I chaired in Maine, and workshops held in New Jersey by Senator Lautenberg.

The Senate bill is a reasonable and measured response to the problem of radon and indoor air pollution as we presently understand it. It will build the solid scientific foundation that is necessary to control radon in the future. It is a better approach than that now belatedly offered by the EPA.

And finally, I want to stress that the legislation passed by the Senate directs the EPA to deal with radon in the broader context of indoor air pollution. It makes sense, in my judgment, to coordinate research on radon with research on other serious indoor pollutants, and it makes sense to coordinate any future radon control programs with control programs for other indoor air pollutants.

The EPA radon strategy makes what I believe to be the serious mistake of addressing radon independently outside of any well-planned program to address indoor air pollution generally. Our legislation deals with and corrects that problem.

I hope that these hearings will lead the House to support legislation similar to or better than that recently adopted by the Senate.

I thank you very much, Mr. Chairman and Mrs. Schneider, for your leadership in this area, and all of the members of the committee for the courtesy in permitting us to be here today.

[The prepared statement of Senator Mitchell follows:]

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STATEMENT OF
SENATOR GEORGE J. MITCHELL

U.S. HOUSE OF REPRESENTATIVES
SUBCOMMITTEE ON NATURAL RESOURCES, AGRICULTURE
RESEARCH AND ENVIRONMENT

OCTOBER 10, 1985

Mr. Chairman, I am very pleased to have the opportunity to testify before the Subcommittee on the important subject of human exposure to radon gas.

I would like to commend the Subcommittee for holding these hearings. We now have clear evidence that exposure to radon is a serious threat to public health. But there is a great deal we do not know about radon. We need to better understand its health effects. We need better information about its location and amounts throughout the country. And we need to develop more reliable methods of controlling radon levels in buildings.

These hearings will help continue to build our knowledge of the many aspects of the radon problem. More importantly, I hope the hearings will be another step toward Congressional action to address the problems posed by radon and other indoor air pollutants.

I am pleased to say that the Senate recently adopted legislation which I introduced this spring with Senators Lautenberg and Stafford. The legislation, titled the "Indoor Air Quality Research Act of 1985" was originally introduced in the House by you and Representative Schneider as H.R. 2101.

As you recall, Mr. Chairman, the Indoor Air Quality Research Act has three major objectives. First, the EPA Administrator is to establish a research program addressing indoor air pollution and radon problems. Research efforts would include collection of data, coordination of the related activities of other Agencies, and assessment of approaches to mitigation measures and alternative control programs.

Second, EPA is to submit to Congress within two years a report summarizing knowledge about this problem, needed further research, and potential actions to mitigate health effects.

Finally, funding of $3 million is authorized to be appropriated for the EPA for the 1986 and 1987 fiscal years.

It is important to note that the legislation does not authorize the EPA Administrator to carry out any regulatory program or any activity other than research and development.

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The legislation finally adopted by the Senate includes several additions to the original bill. For example, the legislation now includes a requirement for an interim report, to be prepared within one year, specifically addressing radon. As part of the interim report, EPA would identify areas with high radon levels and publish information on radon mitigation measures.

Also, the legislation clarifies EPA's authority to conduct demonstrations of radon mitigation measures and directs the Agency to develop mitigation measures for new construction and well as existing buildings.

A final copy of the legislation adopted by the Senate is attached and I request that it be included in the hearing record.

Senate consideration of the Indoor Air Quality Research Act occurred in several phases. Early this year, in budget hearings before the Senate Environment and Public Works Committee, I questioned the Agency about its plans to discontinue in FY 1986 work on indoor air quality and radon which is currently underway. EPA termed this work a "low budget priority".

In August of this year, I chaired a field hearing of the Environment and Public Works Committee in my home State of Maine to hear testimony concerning radon and other indoor air pollutants. Witnesses included the Commissioners of the State Departments of Health and Human Services and Environmental Protection, experts on the chemical characteristics and health effects of radon, and individuals who have experienced high levels of radon levels in their homes.

The hearing confirmed that radon gas is a serious problem in Maine, as well as other parts of the country. Recent studies of radon exposure indicate that as many as 75 people die in Maine each year from lung cancer caused by exposure to radon.

I will be pleased to make a copy of the hearing transcript available to the Subcommittee.

The Indoor Air Quality Research Act gained considerable support over the summer. During that period, 14 Senators co-sponsored the legislation. In addition, the National Lung Association and the Consumer Federation of America endorsed the bill.

Finally, as a result of the efforts of Senator Lautenberg, the Appropriations Committee voted to include $2 million for indoor air quality research in the FY 1986 EPA budget. This funding will assure that EPA is able to implement the bill.

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Senator Lautenberg also held workshops in his home State of New Jersey and has actively worked for sound legislation in this area.

The Indoor Air Quality Research Act was adopted by the Senate on September 18 of this year as an amendment to the Superfund bill.

At about the same time, the EPA announced tentative plans to conduct a national survey of radon. While I am pleased that EPA has, at last, acknowledged the seriousness of the radon problem, the proposed survey falls far short of the balanced and complete program of research on indoor air and radon which is needed.

Mr. Chairman, I hope that these hearings will lead the House of Representatives to pass legislation similar to that recently adopted by the Senate.

The Senate bill is a measured and reasonable response to the problem of radon and indoor air pollution as we presently understand it. The Senate bill mandates a substantial research program by the EPA while keeping our options on design of a national control program open until we have more complete information. In addition, the bill provides for specific attention to the radon problem, while keeping research of radon in the broader context of indoor air pollution.

I will be happy to work with you, Mr. Chairman, or other members of the Subcommittee, to answer any questions you may have concerning the Senate indoor air and radon legislation.

Thank you, Mr. Chairman.

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INDOOR AIR QUALITY AMENDMENT TO
COMPREHENSIVE EMERGENCY RESPONSE COMPENSATION AND
LIABILITY ACT

TITLE IV - INDOOR AIR QUALITY RESEARCH

Sec. 401. SHORT TITLE. - This title may be cited as the "Indoor Air Quality Research Act of 1985".

Sec. 402. FINDINGS - The Congress finds that -

(1) indoor air exposures account for a significant portion of total human exposures to hazardous pollutants and contaminants in the environment;

(2) various scientific studies have suggested that indoor air pollution, including exposure to naturally occurring chemical elements such as radon, poses a significant public health and environmental risk;

(3) high levels of radon have been measured within structures throughout the country and within the Reading Prong;

(4) existing Federal indoor air quality research programs are fragmented and underfunded;

(5) the Environmental Protection Agency's programs on indoor air quality and radon have been hindered by a lack of clear statutory authority for conducting research on indoor air quality; and

(6) an adequate information base concerning potential indoor air quality problems, including exposure to radon, does not currently exist and should be developed by the Federal Government.

Sec. 403. INDOOR AIR QUALITY RESEARCH PROGRAM -

(a) DESIGN OF PROGRAM. - The Administrator of the Environmental Protection Agency shall establish a research program with respect to indoor air quality, including radon. Such program shall be designed to -

(1) gather data and information on all aspects of indoor air quality in order to contribute to the understanding of health problems associated with the existence of air pollutants in the indoor environment;

(2) coordinate Federal, State, local, and private research and development efforts relating to the improvement of indoor air quality; and

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(3) assess appropriate Federal government actions to mitigate the environmental and health risks associated with indoor air quality problems.

(b) PROGRAM REQUIREMENTS. - The research program required under this section shall include -

(1) research and development concerning the identification, characterization, and monitoring of the sources and levels of indoor air pollution, including radon, which includes research and development rating to -

(A) the measurement of various pollutant concentrations and their strengths and sources,

(B) high-risk building types, and

(C) instruments for indoor air quality data collection;

(2) research relating to the effects of indoor air pollution and radon on human health;

(3) research and development relating to control technologies or other mitigation measures to prevent or abate indoor air pollution (including the development, evaluation, and testing of individual and generic control devices and systems);

(4) demonstration of methods for reducing or eliminating indoor air pollution and radon, including sealing, venting, and other methods that the Administrator determines may be effective;

(5) research, to be carried out in conjunction with the Secretary of Housing and Urban Development, for the purpose of developing -

(A) methods for assessing the potential for radon contamination of new construction, including (but not limited to) consideration of the moisture content of soil, porosity of soil, and the radon content of soil; and

(B) design measures to avoid indoor air pollution; and

(6) the dissemination of information to assure the public availability of the findings of the activities under this section.

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(c) ADVISORY COMMITTEES. - The Administrator shall establish a committee comprised of individuals representing Federal agencies concerned with various aspects of indoor air quality and an advisory group comprised of individuals representing the States, the scientific community, industry, and public interest organizations to assist him in carrying out the research program for indoor air quality.

(d) IMPLEMENTATION PLAN. - Not later than ninety days after the date of the enactment of this Act, the Administrator shall submit to the Congress a plan for implementation of the research program under this section. Such plan shall also be submitted to the EPA Science Advisory Board, which shall, within a reasonable period of time, submit its comments on such plan to Congress.

(e) INTERIM REPORT. - No later than one year after the date of this Act, the Administrator shall prepare an interim report providing -

(A) a preliminary identification of the locations and amounts of radon in structures across the United States, and

(B) guidance and information materials based on the findings of research of methods for mitigating radon.

(f) REPORT. -

(1) Not later than two years after the date of enactment of this Act, the Administrator shall, in consulation with advisory committees and groups identified in subsection (c), submit to the Congress a report assessing -

(A) the state of knowledge concerning the risks to human health associated with indoor air pollution, including naturally occurring chemical elements such as radon;

(B) the locations and amounts of indoor air pollutants, including radon, in residential, commercial, and other structures throughout the country;

(C) the existing standards for indoor air pollutants, including radon, suggested by Federal or State governments or scientific organizations and the risk of human health associated with such standards;

(D) the research needs and relative priority

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of these needs;

(E) the potential effectiveness of possible government actions necessary to mitigate the environmental and health risks associated with indoor air quality problems, including radon, in existing and in future structures,

and making such recommendations as may be appropriate.

(2) In developing such report, the Administrator shall consult with the National Academy of Sciences on the scientific issues regarding the quality of indoor air and the risks to human health associated with indoor air pollution.

(g) CONSTRUCTION OF SECTION. - Nothing in this section shall be construed to authorize the Administrator to carry out any regulatory program or any activity other than research, development, and the related reporting, information dissemination, and coordination activities specified in this section. Nothing in this section shall be construed to limit the authority of the Administrator or of any other agency or instrumentality of the United States under any other authority of law.

(h) AUTHORIZATIONS. - There are authorized to be appropriated to carry out the activities under this section not to exceed $3,000,000 for each of the fiscal years 1986 and 1987.

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Mr. SCHEUER. I thank you, Senator Mitchell. I thank the two of you.

I am going to ask you one simple question, and then my colleagues will follow up with any questions.

We understand that we operate in a tight fiscal environment. We understand that this administration is against large spending programs, is against creating new bureaucracies, against Federal programs in particular.

But we have gone out of our way on the House side—and I presume you have done the same thing—to make it clear beyond any question of doubt that we don't have in mind setting up any large spending programs. We are not going to create an IAPP—an indoor air pollution police. What we are going to do is to help cities and States and, above all, individuals—parents, families—we are going to help give them the knowledge by which they can cope with this problem themselves, and the closer to the family they cope with the problem, the better off. We are not going to have any Federal intervention; we are simply giving them knowledge. Knowledge is power, it is often said, and here knowledge is power to achieve some kind of control over your own life, over your o n health outputs.

Since there is really no intent on the part of the House or the Senate to set up any kind of Federal establishment, any kind of Federal bureaucracy, any kind of large-scale spending effort on the part of States or cities, but simply to give individuals, families, parents, and perhaps cities the knowledge to do as they see fit in their own wisdom, I cannot understand why this is not completely consistent with the point of view of this administration, and I cannot understand why they are opposing this legislation with what is admittedly an insignificant amount of funding for a result that could save thousands of American lives every year.

Maybe either of you can enlighten me.

Senator LAUTENBERG. Well, I am sure my colleague has a comment, and I would like to make one, too, please, sir.

Mr. SCHEUER. All right.

Senator MITCHELL. Mr. Chairman, it is ironic that the administration, which in other areas of pollution suggests that the proper answer is more study to build the scientific base upon which to make a rational judgment as to, (a), whether or not control programs are necessary and appropriate, and, (b), if they are, what the nature of those programs should be, should in this area be so reluctant to have the kind of research necessary.

I think specifically of the problem of acid rain, with which I am personally familiar because I am the author of legislation to attempt to deal with that problem. For 5 years, the administration has insisted that we cannot adopt a control program, that much more needs to be done.

While it is true in that area that there remain unanswered questions, it is also true that we know enough to act, and we should proceed as we conduct more research into the area. That is especially significant because there is no substantial direct evidence that acid rain affects human health. We are talking there about damage to natural resources.

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Here we are dealing with what is clearly a present threat to human health, with the possible—indeed, the likely—loss of substantial numbers of American lives as a result of exposure to this pollution. If there were any doubt about the necessity for this kind of research, the fact that we are dealing with people's lives ought to dissipate it.

And so I think it is significant that we are talking here about a very modest program, that $3 million be authorized over a 2-year period under the legislation that we are dealing with, a tiny fraction even of the EPA's research budget, and an infinitesimal fraction of the total research activities of the U.S. Government into other areas which affect human health. It is that factor, I think, which creates the urgency and the need for dealing with it.

I emphasize, as you did, Mr. Chairman, this is a very modest approach. It attempts to obtain the data, the evidence, the science necessary upon which ultimately to make rational public policy judgments on whether we should have a control program and what form it should take if that is appropriate.

Mr. SCHEUER. You are absolutely right. The administration has been saying, on acid rain, two things: Let's do more research, and let the States and cities handle it. Here we have followed that litany. We are doing more research, and we have made it perfectly clear that we intend for the States and cities to handle it. And now they say no, you shouldn't believe what we have been saying on acid rain. It boggles the mind.

Senator Lautenberg.

Senator LAUTENBERG. Just to add to what my colleague said, the fact that it is an immediate health threat. In my own town, we have a radon deposit, unfortunately man made, which the CDC has declared an imminent danger to health.

The fact is that our State, Senator Mitchell's State, Congressman Ritter's State, Congressman Edgar's State, States across the country have dealt with a problem of enormous scope, and here, with a relatively tiny sum of money, we are able to project programs that could have an immediate beneficial effect if people knew what to do.

If you saw what is happening—we had a workshop in New Jersey a couple of weeks ago, and people arrived there. The hall was too small. The fire marshals were turning people away, because there is a sense of panic. We owe it at least to those people to say, OK, you needn't panic, you can work with this problem, here is the general parameter.

The unwillingness of the administration and OMB to go along with that frankly befuddles the imagination. You cannot understand why this is swept along with other programs for a cutback when in fact we spend more than this in saving lives in so many other ways that we can associate with an immediacy.

So I don't understand why. What we have done over in our chamber yesterday in terms of the budget, cutting back programs, just with a meat ax. Programs like this, programs like Superfund are going to affect the health and safety of our citizens, and yet that is not recognized. Time to cut, time to cut, whatever the cost is.

Mr. SCHEUER. Congresswoman Schneider.

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Mrs. SCHNEIDER. Well, I think that, having worked very closely with members of the administration, I think we can say, representatives from the Environmental Protection Agency, scientists from the Department of Energy, folk from the National Academy, a broad spectrum of people, I cannot help but come to the defense of some of these hard-working individuals who are adamant about bringing this information and the research to the forefront of public awareness.

I think, Senator Lautenberg, that you placed the finger of responsibility initially in the right place, and that was with OMB, because I have pushed for funding consistently since 1981, and I am delighted that you gentlemen now are moving on this on the Senate side, and I am quite confident that we are going to be able to move a comprehensive study ahead.

But the attacks that I have gotten year after year on this committee and beyond are simply saying that because of the deficit, No. 1, there is no interest in any new programs, and, No. 2, the same arguments that we heard last night on the floor of the House, on the whole question of a study of civil Federal employees on doing a pay equity.

Now, the reason people were opposed to doing studies on pay equity, and the reason there are some who are opposed to doing studies on indoor air pollution or the extent of the problem of radon, is because of the fear of what the findings might propose, and those findings might very clearly indicate that what we ought to be doing is taking some very drastic and speedy mitigating measures.

It is quite clear, at least from my point of view, I do not at all see any intentions for regulations. But it is also quite clear that the consumer is at risk, and when we look at the cost-benefit analysis, which I think is increasingly more important as we discuss environmental issues, that clearly, the cost-benefit analysis done on indoor air pollution will indicate that it is to our advantage to take these mitigating measures today rather than waiting until tomorrow to deal with the increasing number of lung cancers.

So I am convinced that as we identify the sources of indoor air pollution and also identify the extent of radon exposure, we then indicate what kind of connection exists between radon or other pollutants and human health, and then, third, we make recommendations for mitigating measures.

There are entire industries out there waiting to be of assistance, and I think that much of this has come as a result of our energy crisis, once again a crisis that we responded to without enough forethought, without enough research.

Let us hope the momentum that we are building here today can move us toward this action, so once again we are not dealing with the indoor air crisis and having to spend more money and see more health problems in the future.

Mr. SCHEUER. A vote has just started in the Senate, and the Senators have only about 10 or 11 minutes. If any members have questions—not speeches, but questions— we will take a few minutes to ask questions.

Congressman Torricelli.

Mr. TORRICELLI. Thank you, Mr. Chairman.

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Senator Mitchell, let me say at the outset first that you noted there is an irony in the administration's position. On the contrary, this is perfectly consistent. Whether it is toxic waste or it is radon or it has been a problem of acid rain, they have not found a problem they cannot avoid, and tomorrow has always been sufficient, and this is perfectly consistent in their approach.

I wanted to ask Senator Lautenberg, on this strawman strategy, is there failure to adopt the strategy and implement it because there is an alternative approach the administration has? Is this an example of a competing idea, or are we faced again with rejecting one solution when none is at hand?

Senator LAUTENBERG. What we have got is three proposals, and the strawman is kind of the middle level proposal. It has its funding, as Senator Mitchell indicated, spread over 5 years, about $10 million.

It is the recommendation of EPA that this is the strategy that ought to be followed. And frankly, I cannot find out why there is an unwillingness to go ahead with this program. There is no alternative that is substantially different. Again, it is a modest budget——

Mr. TORRICELLI. So EPA did not make several recommendations to them and they are choosing one of the others? The fact is that they made a recommendation and the administration's real answer is nothing?

Senator LAUTENBERG. They made a recommendation giving three options. This is the middle one, and it is one that EPA feels again, to quote them, that a risk reduction achievable by the strawman strategy, 30 to 50 percent risk reduction, thus avoiding—and the language is very clear—several thousand lung cancer deaths per year.

Mr. TORRICELLI. There has been some attention on the extent of this in Pennsylvania because of studies that have been done that have found, in the areas selected, there has been a 40 percent rate of homes that have seemed to be affected by radon gas, and I have seen estimates of up to a million homes in the United States.

Is there any way to calculate, in New Jersey, the extent of the radon problem?

Senator LAUTENBERG. Well, it is estimated by our Department of Environmental Protection that there are as many 250,000 homes affected in our State, and perhaps even half the geography in our State affected by exposure to radon gas.

Mr. TORRICELLI. Now, finally, as I understand the recommendations from EPA, the role of the Federal Government would be to research both to find answers and the extent of contamination and to locate that contamination.

But those recommendations which now exist for solving the problems in homes can be things that people could do themselves. So this is not a program where the Federal Government would either be entering homes or doing massive construction or massive expenditures.

I have seen estimates of less than $1,000 where people could solve this problem themselves if they knew where the contamination existed and the means that could be taken to solve it. Is that your own interpretation?

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Senator LAUTENBERG. Absolutely right. There is no intention of creating another organizational structure. It is said by many experienced agencies that many of these problems can be solved for hundreds of dollars, but people are panicking because they just don't know what is out there.

It has killed some real estate sales. People have called me. A man called me, a physician, who wanted to move out to one of our counties. He said he was thinking of going there, establishing a practice and buying a home; did I think he ought to run the risk? I said, "I think you ought to find out first."

People deserve to know what is out there for them, not only in our State but States across the country. It is a relatively easy assignment, and we ought to get going with the thing, let the States do what they have to, but give them the knowledge and the experience that we have only in EPA to deal with this.

Mr. TORRICELLI. Thank you.

Mr. SCHEUER. Thank you.

I am only recognizing Congressmen now for questions, since we have a very few minutes left of the Senators' time.

Congressman Ritter is recognized for a question.

Mr. RITTER. Senator, is it your impression that the radon problem is defined with complete similarity to the indoor air pollution problem, or are there some differences that you would detect?

Senator LAUTENBERG. George, do you want to answer that?

Senator MITCHELL. Go ahead.

Senator LAUTENBERG. Senator Mitchell has been an advocate of indoor air pollution research, and I would like him to respond to that.

Senator MITCHELL. I think, as every pollutant is different, so also are there differences in the scope and nature of the problem. But we have previously based activities in terms of research and control into broad categories, and I think it makes sense to do it in a single context.

Mr. RITTER. I think you are right, but would you not admit that the radon dimension to the indoor air pollution problem is a relatively recent component of this total picture in terms of the public awareness, the public perception, the finding of very high levels in the Watras home in Congressman Yatron's district?

Senator MITCHELL. Yes, that is correct.

Mr. RITTER. So I would submit, too, that with this upsurge in the interest in radon, with the findings in the Pennsylvania homes, in the naturally occurring radon, that we are faced with some difference in the strategy for radon mitigation than we are with the strategy for indoor air pollution.

We also have a detection capability with radon because it is radioactive, because we can measure it very precisely. We have that kind of capability which we do not have in indoor air. Would you agree with that?

Senator MITCHELL. Well, obviously, there are differences. I do agree with that. I think you are leading up to disagreeing with me on the question of whether it would be part of a broader context, and I would respect that view.

Mr. RITTER. I don't think I am disagreeing, but what I am trying to do is establish some difference in——

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Senator MITCHELL. Priority.

Mr. RITTER [continuing]. The overall Federal Government role, responsibility and approach that may emanate out of the interest which our ranking member here has expressed for many years on indoor air and the radon problem per se.

Senator MITCHELL. Yes.

Senator LAUTENBERG. I would like to comment if I might, and that is, Congressman, if you are talking about, A, the immediacy, B, the recognition of the fact that radon is here, it is dangerous, that it is not a new subject by a long shot; it was associated with uranium mining; it was recognized that lung cancer susceptibility was very high among those people. The discovery that was recently made was that it was in a home, the Watras home, as you describe it, in Congressman Yatron's district.

Mr. RITTER. So what I am trying to point out is——

Senator LAUTENBERG. If I might, just one second——

Mr. RITTER. Oh, I am sorry. I thought you were finished.

Senator LAUTENBERG. That is that it is here, that it is recognized; we can save lives; and I think, in fairness to the interest of my colleague, that I believe that this is somewhat different, that we all recognize that it is an imminent danger, and that we can proceed with a relatively modest program.

You can detect a radon depth in a home for as little as $50 with an instrument that our DEP says is reliable. So we ought to get on with it, and we ought to relieve the concerns and anxieties of the citizens who will benefit from that.

Mr. RITTER. There is even a $10 instrument. I guess the point I am making is, my letter to EPA calling for this study—and Congressman Yatron and Congressman Edgar and I have been in this kind of from the outset, so we are sort of riding on this wave. This is all relatively recent. Our work with the EPA, their response to us, this $11 million program—it all seems to me that there isn't really any great mystery as to who has been hindering or obstructing what, but we are getting our ducks in order. We are getting the information together. We need to analyze the relative hazard and the location of that hazard and take action before we dig up every basement in the Reading Prong.

So I have a feeling that some of us on the House side, and now along with yourself, have moved pretty fast on this, and this EPA study that is written up this morning and that quotes you, Senator Lautenberg, is fairly much on target.

I don't see any reason not to go ahead with it, and I think you are right, Senator Lautenberg, that there will be somewhat of a respective difference in speed going ahead on radon versus this other wide universe of indoor air, although I personally am a very strong supporter of going ahead with the indoor air program.

Mrs. SCHNEIDER. Would the gentleman yield, please?

Mr. RITTER. Certainly I will yield.

Mrs. SCHNEIDER. Only because we have had the benefit of numerous hearings on this topic, I would caution my colleagues and those in the Senate to recognize that to separate the two, radon from indoor air, is, from my opinion—and, I think, many of the scientists that we will hear from later on—not the best approach, be-

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cause what we need to look at is the synergistic reactions of many of these pollutants that are in the indoor air environment.

Granted, we have substantial evidence now that leads us to mitigating measures on a crisis basis, and yes, we need to look at those, but at the same time, we should not be pooh-poohing the potential threat of indoor air.

Mr. RITTER. If the gentlelady will yield back, I wish to agree with her and yield back to the chairman.

Mr. SCHEUER. Thank you very much.

Senators, thank you very, very much. We appreciate your coming over.

Senator MITCHELL. Thank you very much, Mr. Chairman.

Senator LAUTENBERG. Mr. Chairman and members of the subcommittee, thank you.

Mr. SCHEUER. Now we will go back to opening views, and I am going to urge my colleagues—we have a long list of witnesses, and we have a rollcall vote coming up.

Mr. EDGAR. Mr. Chairman.

Mr. SCHEUER. Yes.

Mr. EDGAR. Before we break for a vote, I must run, and I appreciate the opportunity to be here.

The Public Works and Transportation Committee this morning passed out a Superfund bill that began to move toward the House floor. It is now out of Energy and Commerce; it is now out of Public Works and will be on the House floor within the next 25 days.

In that bill, we were able to place in an amendment which was supported by my colleagues, Don Ritter and Gus Yatron, which provides for two things. One is for EPA to identify the level at which radon exposure is negative to the health. Second, it sets up a demonstration project of $4 million to address the problem of trying to renovate homes and ventilate houses, particularly in the Reading Prong area.

While you have a friend in Pennsylvania, you also have an enemy, and that happens to be radon gas.

I think we are beginning to move in some significant ways on this issue, and I just wanted to report to your subcommittee that there is a provision in the Superfund bill to do those two things.

Mr. SCHEUER. I thank my colleague.

Congressman Jim Courter of New Jersey.

Mr. COURTER. Thank you, Mr. Chairman. I appreciate it. I will be very, very brief.

I, as well, had kind of a town meeting on the radon problem in my area of New Jersey, and it attracted, I would say, about 550 people. It is an issue that the people are concerned about. I wouldn't really characterize it as panic at all. I think the citizens that came to my town meeting, generally, genuinely were concerned. They were calm, and they wanted to get as much information as they possibly could.

I think that Claudine Schneider was absolutely correct. You cannot really separate the issue of radon from the issue of indoor air pollution. I know it was the policy of various administrations to assist in the energy problem in this Nation by encouraging houses to button up, increase insulation, which may have been the wrong

policy. It may certainly be a contributing factor to the danger of the degree of radon that we have today.

Also, I might suggest to my colleagues and my good friends that the Congress and the administration are two different bodies. You have the administrator and the executive and the legislative, and we don't have to sit here and wait for OMB to bless something.

I think that there is no doubt about the fact that here in the Congress we can indeed pass good pieces of legislation proposed by Bob Edgar, Claudine Schneider, and others, and we should get on with the process of legislating here in Congress, as we sometimes enjoy doing and we should in this particular case.

Mr. Chairman, it is a pleasure for me to be here. If I cannot be here for all the hearings, I look forward to reading the prepared comments of those witnesses that you have. Certainly it is a situation that has gotten, finally, the attention of, I think, not only the administration but Members of Congress as well.

Thank you for having me here, Mr. Chairman. I appreciate it.

Mr. SCHEUER. Thank you, Congressman.

Congresswoman Jan Meyers of Kansas.

Mrs. MEYERS. I have no opening statement, Mr. Chairman. In the interest of time, I will just say that I do agree with many of the things that my colleagues have said, and I look forward to the hearing.

Mr. SCHEUER. Thank you.

Congressman Ham Fish of New York.

Mr. FISH. Thank you, Mr. Chairman, and I want to thank you very much for inviting me to be a guest at this hearing.

As you will remember, I had the pleasure of serving with you for several years on the Science and Technology Committee, and during that time, indoor air quality was a major issue before us, and we were all aware that the tightening of home insulation for energy conservation purposes might have unforeseen ramifications.

I am delighted to see this timely action that you, Mr. Chairman, and the ranking minority member of this committee, Claudine Schneider, are taking in holding this hearing to assess the public risks of radon exposure in residences, particularly in response to the Reading Prong problem that has emerged in recent months.

As you know, several counties in our State of New York, in southeastern New York, that I and Congressman Dan Gilman represent, are situated on the Reading Prong, and we are grateful to you and this committee that you are taking such quick action in alerting us to the important public health consequences.

Thank you, Mr. Chairman.

[The prepared opening statement of Mr. Fish follows:]

OPENING STATEMENT OF HON. HAMILTON FISH, JR.

Mr. Chairman, I'd like to thank you for inviting me to be a guest at this hearing. As you know, when I had the pleasure of serving with you on the science and technology committee, indoor air quality was a major issue before us. We were well aware that the tightening of home insulation for energy conservation purposes might have unforseen ramifications on indoor air quality.

I am glad to see the timely action that you, Mr. Chairman, and the ranking minority member of this committee, Claudine Schneider are taking in holding this hearing to assess the health risks of radon exposure in residences—paticularly in response to the Reading Prong problem that has emerged in recent months. As you

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know, several counties in southeastern New York that I and Congressman Gilman represent are situated on the Reading Prong. We are grateful that this committee is taking such quick action in alerting us to this important public health problem.

Mr. SCHEUER. Thank you very much, Congressman.

We are in the middle of a rollcall vote now, as I said, and we are going to suspend now. We have finished the opening statements of all the members. We are going to suspend now for 15 minutes, and when we are back, we are going to commence with the first group of witnesses.

[Recess taken.]

Mr. SCHEUER. The hearing will resume.

We have two more very distinguished Members of Congress from whom we are going to hear brief opening statements before going to the first panel.

Congresswoman Marge Roukema of New Jersey.

Mrs. ROUKEMA. If your distinguished Representative can find her seat, I will be distinguished.

Mr. Chairman, I do appreciate your hearings here today and certainly give the credit to you and to the ranking Republican, Mrs. Schneider, for your fine work in this area.

The Reading Prong is a well known geological formation that has caused much concern not only in Pennsylvania but certainly in the State of New Jersey. In my congressional district, the fifth district, it has been estimated in a recent study by the New Jersey Department of Environmental Protection that as many as 18 municipalities may be affected, and in those municipalities there are upwards of 150,000 homes directly involved. And so we can see that the potential in New Jersey and across the country is vast.

I am sorry that I was not here earlier to hear our State senator, Senator Lautenberg, make his comment, but certainly I am aware of the legislation that he has introduced and attached to the Superfund on the Senate side, and a similar effort is under way on the House side, and I certainly endorse those efforts.

Clearly, for my representatives and hundreds of thousands of residents throughout the country, it is essential that they have accurate information with which to both allay their fears and take the necessary steps to reduce the hazards, whether in their homes or their communities.

And so I am most anxious, Mr. Chairman, to be here and to hear the governmental representatives give their assessments and testify as to the actions they are prepared to take.

I thank you.

Mr. SCHEUER. Thank you, Congresswoman.

Mrs. ROUKEMA. I ask unanimous consent that the full text of my comments be inserted in the record.

Mr. SCHEUER. Indeed; it is so ordered.

Mr. RITTER. Thank you.

[The prepared statement of Mrs. Roukema follows:]

STATEMENT OF CONGRESSWOMAN MARGE ROUKEMA

Mr. Chairman: At the outset, I would like to acknowledge the efforts of the Members of the Subcommittee on Natural Resources, Agricultural Research and Environment and thank you, Chairman Scheuer, for allowing me the opportunity to participate in this important hearing. I also want to recognize the work of the Gentle-

lady from Rhode Island, Congresswoman Schneider, who has had a long-term interest in this and related issues.

We are conducting this hearing to gather information on an environmental hazard that is little understood, but offers a significant threat to public health. As outlined by the Chairman and my Colleagues, radioactive radon gas has been detected in homes in New Jersey and Pennsylvania at levels well above the safe exposure standards developed by the Occupational Safety and Health Administration (OSHA) for uranium miners. It is quite likely that similar pockets of radon concentration will be discovered in other areas of the country.

While we can reasonably assume that this is clearly an unacceptable exposure level for residents of these affected homes, we do not have an accurate assessment of the health risks posed by radon. Today, when it comes to radon, there are very many questions, but not very many answers.

For example, there is compelling evidence that extended exposure to radon gas increases the incidence of lung cancer in uranium miners. However, no such study has been undertaken to determine the effects of radon exposure in the home environment. In addition, no one really knows how many homes in the nation contain detectable levels of radon gas.

Today, we have only estimates of how many homes are potentially affected by a build-up of radon and those numbers are alarming. In New Jersey, the Fifth Congressional District which I represent lies directly over the so-called Reading Prong. A recent study by the New Jersey Department of Environmental Protection identified 18 municipalities in my District, containing over 150,000 homes, that could be potentially affected by this problem. The residents of these homes deserve to be accurately informed of any risks they may be facing.

In this instance, where scientific uncertainty still obscures scientific fact, it is incumbent on government to meet the needs of its people for information and informed advice on the radon threat.

To its credit, the New Jersey Department of Environmental Protection has established a Radon Hot Line to disseminate information to homeowners. Over the last several weeks, hundreds of residents of Northern New Jersey have been calling State agencies to learn of the potential risks to their health.

Clearly, the federal government has the resources to assess the nature and the magnitude of the problem posed by radon gas. I endorse efforts in both the House and the Senate to include funding for a nationwide radon survey in Superfund reauthorization legislation. I further encourage the Department of Energy and the Environmental Protection Agency to use conditions in the Reading Prong as a laboratory; to expedite study of the problem and to share its findings with the States of New Jersey and Pennsylvania, to allow residents to address what could be a serious threat to their health.

I thank you, Mr. Chairman.

Mr. SCHEUER. That also goes for Congressman Yatron if he has a prepared statement.

Congressman Gus Yatron represents the Reading Prong and has been one of the most active and concerned and involved Members in providing leadership for the Congress to face up to this problem squarely and give the people the knowledge to solve the problem at the local level.

Gus, I thank you for your leadership, and I am delighted to have you here today for some opening remarks.

Mr. YATRON. Thank you very much, Mr. Chairman and members of the subcommittee.

I would like to thank you and commend you for holding this hearing today. Several months ago, my colleagues, Congressman Ritter and Congressman Edgar, and I asked Chairman Scheuer to conduct a hearing on radon. At the time, the subcommittee's commitments and hearing dates were filled, and I know that Chairman Scheuer worked very hard to make this time possible and available to us, and I am grateful for the consideration and know that many of my constituents, especially the four who are here today, are also very appreciative.

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Mr. and Mrs. Stanley Watras and Ms. Kay Jones and Ms. Kathy Varady traveled from Boyertown, PA, to be here today. As residents of homes on the Reading Prong, they are all, unfortunately, quite familiar with the problems and hazards posed by radon gas contamination. Their homes are or were contaminated by radon at levels far above the safe range. For their courage in facing these dangers and for their perseverance and many efforts to help us understand and better address this compelling environmental problem, I commend these citizens.

The problem before us involves complex public policy issues and grave public health concerns. What makes radon contamination such a difficult problem is both its origin—it arises from naturally occurring uranium deposits—and its location—it poses its greatest threat in the realm of the home, where existing governmental regulations have never been applied.

While we therefore have no legal precedent, we must, nevertheless, be very clear about what our responsibilities are. The inhalation of radon gas leads to lung cancer, and as such it represents one of the most serious environmental threats we know.

The Centers for Disease Control has been quite cautious in its statements about the risks posed by radon but, in reply to an inquiry I made to CDC, acknowledges and warns, and that quote is, "Living in a home contaminated with radon above recommended levels is likely to pose a serious hazard to an individual's health."

It is this risk to human health that we must acknowledge and address. At this point, our laws give us no authority, and our policies and programs are ill equipped to adequately and appropriately reduce these risks.

From the beginning, this problem has defied easy remedy, primarily because of concern about the potential costs that are involved. But the health risks here are too great, and if we do not act, the cost of not minimizing them will come back to haunt us in the future.

I again encourage EPA and DOE and other appropriate Federal agencies to upgrade their programs and to begin to treat radon contamination of the home with the sense of urgency that it certainly requires. I also urge all of our colleagues to continue to work to amend our environmental protection laws in order to create the necessary authority for the Federal Government to fully respond to this grave public health concern.

Thank you, Mr. Chairman.

Mr. SCHEUER. Thank you very much, Congressman Yatron, and I want to assure your constituents that there is no more embattled protector of their right to know the details of their exposure and the implications of their exposure to their own health than their own Congressman. You are not only helping all Americans by your efforts to defend their own health and to protect their own health, but you are certainly doing that for your own constituents, and we are very grateful for your leadership.

We will now call the first panel. We are going to have three panels. The first is the citizens panel. Then we are going to have a panel with Federal and State experts, and then we will have a panel of nongovernment experts.

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So this is the first of three panels: Ms. Kay Jones, president of Pennsylvanians Against Radon, Boyertown, PA; Mr. and Mrs. Stanley J. Watras, Boyertown. PA; Mr. Richard Barnola, Emmaus, PA. Ms. Kay Jones will be accompanied by Kathleen Varady, vice president of Pennsylvanians Against Radon. Will all of you please come to the witness table.

We are very late. We are already 1½ hours into our hearing, and we have yet to hear the first witness. So we are going to restrict witnesses and the Members of Congress up here strictly to 5 minutes.

We will start out first with Mr. Stanley Watras of Boyertown, PA. Let me say to all of the witnesses that the full text of your prepared remarks will be printed at the point in the record at which you speak.

Let me also say, so I don't have to repeat it to all of you, we are extremely grateful that all of you, who are busy men and women with your job responsibilities, your family responsibilities, your civic responsibilities, we are very grateful to you to have taken time out of your busy schedules to come down and enlighten us, the Members of Congress.

That, of course, is the purpose of these hearings—to give us the knowledge by which we can legislate intelligently and sensitively—sensitively to the problems that are of concern to you. So you are playing a vital role in giving Congress the information by which it does the work of representing the American people. We are very grateful to you.

Please proceed, Mr. Watras.

STATEMENT OF STANLEY J. WATRAS, RESIDENT OF BOYERTOWN, PA

Mr. WATRAS. Thank you, sir.

Our experience with radon is so enormous that most of our allotted time here today would be spent recapping events that are described in our written testimony, but briefly. I will summarize.

I am a senior construction engineer employed at the Limerick Generating Station, which is a nuclear power facility located near Pottstown, PA. I am the individual who set off radiation detectors at the Limerick Generating Station, indicating that all of my clothes and skin surfaces were saturated with high levels of radioactive contamination.

The source of my contamination was ultimately traced back to my home at 199 Indian Lane, Boyertown, PA, where the highest indoor radon levels ever recorded in the United States were found.

The Pennsylvania DER test results indicated radon daughter measurements of 13.5 working levels in my basement, 12.4 working levels in my family room, 9 working levels in my living room, and 8.65 working levels in our bedrooms. These results are incomprehensible when you consider the fact that the safe level is considered .02 working levels.

Living within the environment of our home would add an annual risk of death to lung cancer of approximately 13 percent and a lifetime risk of death due to lung cancer of 585 percent. This is equiva-

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lent to smoking approximately 135 packs of cigarettes a day or having 455,000 chest x rays per year.

This was by far the most horrifying situation we experienced in our lives. At first we were confronted with the unknown, with so little information available to us that we did not fully understand this potential killer. This is why public awareness is so very, very important. It is hard enough to psychologically deal with a problem of this magnitude informed; uninformed, it was really almost unbearable.

Now, in Pennsylvania, there is literature available to the potential affected homeowners. But how about all the other potential homeowners throughout the remainder of the United States? I would venture a guess that most people never heard of the word "radon," even though radon may be killing them right now.

That is why I feel that the Federal Government should establish a public awareness program throughout the entire United States and make the word "radon" and its harmful effects household words.

But public awareness is beneficial only if the total scope of the problem is defined and identified. This is why I feel that the Government should establish a nationwide testing program in order to define and inform the affected homeowners throughout the entire United States.

But national public awareness and testing programs may only lead to public panic if continued research and financial aid programs are not considered collectively. Presently, the domestic long-term medical effects are inconclusive. There are only mathematical straight-line extrapolations using data collected from uranium miners. But is uranium miner data directly correlated to domestic exposure? I don't know.

This is why I feel that the CDC should acquire additional funding for medical research in order to define the medical effects of domestic exposure to radon and radon daughters. Also, continued governmental emphasis, but on a much larger scale, should be put on the funding of the development of more cost effective means of ridding affected homes of this deadly natural phenomenon.

Since present cost estimates for the higher levels of homes in our area ranged into the five-digit area, this really makes it extremely difficult for the average person to afford. This leads me into a discussion of financial aid that is so desperately needed by the general public to rid their homes of this gas.

I feel that the Federal Government has a moral obligation to help and protect its citizens by any means, including financial aid. What is the difference between this problem and a tornado, hurricane, or flood? There is none. There are only law abiding, innocent people being hurt by something that they have no control over.

Is there any difference between this problem and the federally funded uranium mill tailings projects? Yes. This is due to natural occurrences, and this problem has radiation levels hundreds of times higher. If the Federal Government justified the funding of remediation programs with radiation levels hundreds of times lower than these, then why are they so reluctant to provide funding for this problem? Possibly it may be due to the fact that this problem may dwarf the others in its magnitude and cost billions of dollars.

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This is why we have to gather together all of our scientific resources, both governmental and private, because we potentially have a crisis situation right now. Presently, there are only service organizations offering methods to remediate homes of gases.

Mr. SCHEUER. That was the bell, but just finish summarizing your testimony.

Mr. WATRAS. Another thing, I would suggest that the Federal Government offer large tax credits to privately owned product organizations, not service organizations, such as E.I. du Pont, Dow Chemical, ICI America, the scientific backbone of our country, to develop low-cost products to help out our community.

[The prepared statement of Mr. Watras follows:]

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TESTIMONY GIVEN BY

STANLEY J. & DIANE M. NATRAS

TO THE U.S. HOUSE OF REPRESENTATIVE

SUBCOMMITTEE ON NATURAL RESOURCES,

AGRICULTURE RESEARCH AND ENVIRONMENT

October 10, 1985

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My name is Stanley J. Watras. I am a Senior Construction Engineer and have been employed by Bechtel Construction, Inc., San Francisco, California since July 14, 1975. I am presently assigned to the Limerick Generating Station, Pottstown, Pennsylvania, which is a nuclear power facility owned and operated by Philadlephia Electric Company, Philadelphia, Pennsylvania. I have been granted a security clearance allowing me unrestricted/unescorted access into the vital areas of this nuclear power facility during its' testing and subsequent operational modes. Unit #1, Limerick Generating Stations's radiation monitors were activated in early December, 1984, approximately 3 to 4 weeks prior to Unit #1's initial criticality, and my normal work activities require me to pass through these radiation monitors daily when working in Unit #1. Since the first day these monitors were activated, I constantly tripped every alarm on all zones, thus indicating the presence, on my entire body, of high levels of radioactive contamination. Philadelphia Electric Company's subsequent analysis determined that all of my clothing and all of my skin surfaces were highly contaminated with isotopes of natural background radiation, which was totally unrelated to the proposed operations at the Limerick Generating Station.

At first, I was not overly concerned. But, because of my subsequent constant tripping of the radiation monitor alarms, I soon grew annoyed and apprehensive. I became annoyed with the

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fact that everytime I entered into Unit #1, I would have to idly spend 3 to 4 hours in the job site's decontamination facility or at an assigned location decaying down to a level of contamination that would allow me to exit. This proved to be the turning point in my life. It was then that I first suspected that the source of my contamination may be my home. On December 13, 1984, I told my wife that the following morning I was going to put myself through a test. Then on December 14, 1984, I traced every step I made from my home to the job site. Upon entering the job site, I walked into the Technical Support Center, turned around and walked out. I did not even enter into the Power Block (Reactor Building, etc.). At that time, I once again tripped the portal monitor on all zones, thus indicating that I was highly contaminated from the underside of my shoes to the top of my head. When that alarm went off, I knew I was bringing it in from home. I then asked Philadelphia Electric Company to test my house in order to confirm my suspicions. As requested by Philadelphia Electric, on December 17, 1984, I brought in a water sample from my home and had it analyzed at the job site's Chemistry Lab. The results showed elevated, but not overly harmful levels of radioactive lead and bismuth. Then on December 19, 1984, Philadelphia Electric tested the air quality of my home and found that my living room contained a Radon daughter measurement of 16 Working Levels (WL). Philadelphia Electric Company quickly contacted the Pennsylvania Department of Energy Resources to inform them of the situation. Pa. DER at that time

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made an appointment with me for December 26, 1984 to test my house in order to confirm Philadlephia Electric Company's data. Since these levels seemed unrealistic to me, I asked Philadelphia Electric to retest my home, which they did on December 21, 1984. These test results showed Radon daughter measurements of 22 Working Levels in my basement, 14 Working Levels in my living room and 9 Working Levels in our bedrooms.

On December 26, 1984, the Pa. DER came to my house and installed a combination of 19 TLD's and track etches. They also took numerous 5 minute air samples, soil samples, water samples and scrappings of the inside of my basement wall. One week later, on January 2, 1985, the Pa. DER removed the combination of 19 TLD's and track etches. Three days later, on January 5, 1985, the Pa. DER issued us a letter in person highly requesting that my family move out of our house. On January 6, 1985, we moved out of our house and into a nearby motel. Pa. DER's test results indicated Radon daughter measurements of 13.5 Working Levels in the basement, 12.4 Working Levels in the family room, 9 Working Levels in the living room and 8.65 Working Levels in our bedrooms. These results are incomprehensible when you consider the fact that a safe level is .02 Working Levels. Living within the environment of my home would add an annual risk of death due to lung cancer of 13% and a lifetime risk of 585%. This is equivalent to smoking 135 packs of cigarettes a day or having 455,000 chest x-rays per year. It is obvious from this

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staggering data that Philadlephia Electric Company, by discovering this problem, saved my life and the lives of my wife and my two young sons. For this, I am indebted to them for life.

This incident spearheaded the implementation of a governmental testing program of homes in the surrounding areas, which indicated that approximately 40% of the almost 2900 homes tested as of the end of August had above acceptable levels of Radon, with my house being by far the highest ever found.

On April 16, 1985, Philadelphia Electric Company held a press conference and publicly announced that they would fund a research project, using my house as a subject to possibly develop national standards for the reduction of Radon gas concentrations in homes. The project began shortly afterwards and was essentially completed in June with testing to follow. On July 3, 1985, the Pa. DER and Philadelphia Electric held a press conference to publicly declare that my home had been restored to an inhabitable condition. My family moved back into our house shortly afterwards.

This was by far the most horrifying situation we have experienced in our entire lives. At first, we were confronted with the unknown, with so little information available to us that we did not fully understand this potential killer. That is why public awareness is so very important. It is hard enough to psychologically deal with a problem of this magnitude informed;

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uninformed was almost unbearable. Now, in Pennsylvania, there is literature available to the potential affected homeowner, but how about the other potentially affected homeowners throughout the remainder of the United States. I venture a guess that most people never heard of the word Radon, even though Radon may be killing them right now. What they don't know may be hurting them. Can these people rely on another Stan Watras with a similar set of circumstances - - - - NO!!! That is why I feel that the Federal Government should establish a public awareness program throughout the entire United States and make the word Radon and its harmful effects household words.

Public awareness is beneficial only if the total scope of the problem is defined and identified. Human nature is such that one feels that "something like that could never happen to me" even though it may be happening to them right now. They just have not been identified yet. That is why I feel the government should establish a nationwide testing program in order to define and inform the affected homeowners throughout the entire United States.

National Public awareness and testing programs may only lead to public panic if continued research and financial aid programs are not considered collectively. Presently, the domestic long term medical effects are inconclusive. There is only mathematical straight line extrapolations using data collected from uranium miners. But is uranium miner data directly

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correlated to domestic exposure?? I don't know and I don't know of any MD who would make sound medical judgement using this presently known data. That is why I feel that the CDC should acquire additional funding for medical research in order to define the medical effects of domestic exposure to Radon/Radondaughters. Also, continued governmental emphasis, but on much larger scale, should be put on funding the development of more cost effective means of ridding affected homes of this deadly natural phenomena, since present cost estimates for the higher level homes in our area have ranged into the 5 digit area. This makes it extremely difficult for the average person to afford.

This leads me into a discussion of the financial aid that is so desperately needed by the general public to rid their homes of this gas. I feel that the federal government has a moral obligation to help and protect it's citizens by any means possible, including providing financial aid. What is the difference between this problem and a tornado, hurricane or flood? There is none. There is only innocent, law-abiding people being hurt by something that they have no control over. Is there any difference between this problem and the federally funded uranium mine tailing projects? Yes, this is due to natural occurrences and this problem has radiation levels hundreds of times higher. If the federal government justified the funding of remediation projects with radiation levels

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hundreds of times lower than these, then why are they so reluctant to provide funding for this problem? Possibly, it may be due to the fact that this problem may dwarf the others in magnitude and cost billions of dollars. That is why we have to gather together all of our scientific resources, both governmental and private, because we potentially have a crisis situation. Presently, there are only service organizations offering methods to remediate homes of this gas. I suggest that the federal government offer large tax credits to privately owned product organizations, such as E. I. Dupont, Dow Chemical, ICI America, etc., the scientific backbone of our country, to develop low cost products that when applied would significantly reduce the infiltration of this gas. They may even consider using identified affected homes as test laboratories. I feel that there is nothing wrong with offering private industry financial incentives in order to develop low cost scientifically innovative products that would help the public.

All of the aforementioned discussions were focussed around existing structures. I also feel that the federal government should enact a uniform building code in potentially affected areas that would address known Radon remediation methods. This would prevent this problem from getting any larger.

In summary, I feel that the federal government should enact a uniform building code that addresses radon remediation techniques, fund public awareness programs, fund nationwide

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testing programs, fund medical and remedial action research, provide financial aid to the identified affected people and provide financial incentives to our private scientific community to develop low cost products.

Diane and I feel that all of the psychological, emotional and physical damage we experienced would all be worth it if even one life can be saved in the process, but in order to accomplish that, the federal government's help is needed - - - please listen to my plea.

Thank you,

Stanley J. Watras

Stanley J. Watras

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Mr. SCHEUER. Thank you very much, Mr. Watras.
Mr. Richard Barnola.

STATEMENT OF RICHARD BARNOLA, REALTOR, EMMAUS, PA

Mr. BARNOLA. Thank you, Mr. Chairman and subcommittee.

As a realtor and a homeowner in the Reading Prong area of Pennsylvania, I am not only concerned about the effects of radon on the health of my family and myself and everybody else but also with its economic impact.

More specifically, I am concerned about how the negative publicity on radon has affected property values in the "radon belt," a term given to the Reading Prong based on a Geological Survey map showing a defined area of uranium-bearing rock formations. I believe this was done back in the 1970's.

This map shows gamma ray anomalies detected during a carbon—and I can't even say this word—scintillometer survey for radioactive mineral resources. It is widely believed that this well-defined area has a propensity for higher than normal radon activity.

This map has been published numerous times in the Call Chronicle, our area's major daily newspaper. If you would bear with me, I would just like to show you a typical article which has appeared locally, along with many others. This is a map of the Reading Prong, the so-called radon belt. As you can see here, it is labeled "Lehigh Valley Radon Belt." This lists every road within that area that the study was done on.

This article came out on September 22, 1985, and as you can see, it is a full page. Actually, it was three pages. This survey indicated all the roads that had normal or higher than normal levels of radiation. This has created a great degree of anxiety, fear, and confusion among property owners, not to mention the fact that I am sure it has scared the hell out of potential property buyers.

Being a lay person, I have no idea how "higher than normal"—that is in quotes—levels of radiation measured by a scintillometer mounted on a moving vehicle over an open road correlates to unsafe radon levels measured by various other devices such as a track-etch detector which is used in a closed environment like a sealed basement of a home.

I do know that if I lived on one of these roads, as mentioned in this article, or was about to purchase a home or land on one of these roads, I would certainly be very concerned. But should I be? So far, only about 40 percent of the homes along these roads were tested as having above safe levels of radon.

More interestingly, many homes, several school buildings, as well as other public buildings well outside of this defined area called the Reading Prong, have had readings higher than acceptable.

Shouldn't I be concerned about radon in any location? The EPA reported in June that no fewer than 11 toxic air pollutants may pose a threat to the average home. These are believed to be generated by common household products and building materials. I wonder what they are, and shouldn't I be concerned about them?

Being a realtor and given the responsibility of having to market real estate in or about the Reading Prong, I am also very con-

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cerned about the legal and ethical ramifications of the radon question.

The following is an excerpt from a memorandum dated August 27, 1985, distributed to all broker/owners belonging to the Allentown-Lehigh County Board of Realtors.

I quote:

> Radon. This is a subject which has been given widespread publicity in recent months. Each broker/owner has recently received a packet of information forwarded by the board and furnished by the Department of Environmental Resources outlining what radon is, what health hazards it may cause, and the general location which is affected by radon.

I would like to just hold up a copy of this memorandum. It is a five-page, very informative and, I think, very good memorandum, but again, it does outline a very specific area known as the Reading Prong or the Lehigh Valley radon belt, very definite.

Mr. SCHEUER. Does it inform people as to what they can do themselves to their homes to radically reduce the amount of radon to which they are exposed?

Mr. BARNOLA. Yes, sir, that is correct. It does. It is informative, and I have no problem with that. My only problem is that it is defining an area, and it is being very specific in defining an area, as almost like a combat zone, a very definite area.

If I can be allowed to finish this, I have one more page and I can wrap this up.

Mr. SCHEUER. Yes. Will you summarize?

Mr. BARNOLA. I will try to.

Basically, this paragraph is telling a real estate agent that he had better beware when he goes to show a home that is located in this well defined area, and certainly he should beware.

But the problem is—well, actually, the contents of this memorandum obviously are based on good will and good intentions. It is both designed to protect the public and the realtor. But again, what it is telling the realtor is, stay out of this area. It is a redlining effect of this area, and it is doing untold damage to possibly very, very innocent real estate owners.

Based on what I have been able to determine, we don't really know enough right now about the incidence, the measurement, the effect, and the geography of radon. And aren't we being a little bit premature in targeting a defined geographic area as being a health hazard when the fact is there is no safe standard for residential dwellings?

Am I not doing a disservice to my selling client who may have had his home tested legitimately as safe by telling a would-be buyer that his home is in an area known to be a hazard? The typical buyer in this situation, although he is certainly concerned about the health, he is also concerned about the resale value, and if he knows——

Mr. SCHEUER. I am going to have to ask you to sum up.

Mr. BARNOLA. All right. In summary, I believe that what we must do before we can target areas as being a health hazard is to assemble more information, create a universally acceptable definition of what is safe for a residential dwelling.

I think we also must recognize that targeting a specific area is not in the best interest. I think we do realize that this problem of

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radon as we now see it, our knowledge of it is limited to areas that, for one reason or another, we have had to study because we have recognized the problem.

But is it not possible that this problem is more widespread, and shouldn't we determine this before we do zero in on a specific area, which may very well hurt a select group of people where it hurts the most, or secondmost, second to health, and that is economically?

Mr. SCHEUER. Mr. Barnola, I am sorry to interrupt you, but in deference to other witnesses, I am going to have to do that.

Mr. BARNOLA. I quit. Thank you.

[The prepared statement of Mr. Barnola follows:]

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As a Realtor and a homeowner in the "Reading Prong" area of Pennsylvania, I am not only concerned about the effects of Radon upon the health of my family and myself, but also with its economic impact. More specifically, I am concerned about how the negative publicity on Radon has affected property values in the "Radon Belt," a term given to the "Reading Prong" by the Commonwealth of Pennsylvania's Department of Environmental Resources based on a geological survey map showing a defined area of uranium bearing rock formations. This map shows gamma ray anomalies detected during a carborne scintillometer survey for radioactive mineral resources. It is widely believed that this well defined area has a propensity for higher than normal radon activity. This map *** has been published numerous times in the Call Chronicle, the area's major daily newspaper. In fact, on September 22, 1985, a full page article appeared specifically naming all roads that the survey indicated as having higher than normal levels of radiation.*** This, as well as many other articles on the subject, have caused a great deal of anxiety, fear and confusion among property owners; not to mention it scared the hell out of potential real estate Buyers. Being a lay person, I have no idea how "higher than normal" levels of radiation measured by a scintillometer mounted on a moving vehicle over the open road correllates to unsafe Radon levels measured by various other devices such as a Track-Etch detector in a closed environment like a sealed basement of a home. I do know that if I lived on one of those roads, or was about to purchase a home or land on one of those roads, I would certainly be concerned. But should I be? So far only about 40% of the homes along those roads that were tested have been found to have above "safe" levels of Radon. More interestingly, many homes, and several school buildings well outside of the Reading Prong have had readings higher than acceptable. Shouldn't I be concerned about Radon in any location? The EPA reported in June that no fewer that 11 toxic air pollutants may pose a threat in the average home, these are believed to be generated by common household products and building materials. I wonder what they are, and shouldn't I be concerned about them?

Being a Realtor given the responsibility of having to market Real Estate in or about the Reading Prong, I am concerned about the legal and ethical ramifications of the Radon question. The following is an excerpt from a memorandum dated August 27th, 1985, distributed to all Broker/Owners belonging to the Allentown-Lehigh County Board of Realtors...

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RADON. This is a subject which has been given widespread publicity in recent months. Each Broker/Owner has recently received a packet of information forwarded by the Board and furnished by the Department of Environmental Resources outlining what Radon is, what health hazards it may cause and the general location which is affected by Radon. It is of utmost importance all Brokers be aware that this potential safety issue should be identified if known by the Seller to prospective purchasers. It may be sufficient to simply indicate in the remarks section that the listing office should be contacted prior to any showing of this property and then a discussion indicating that radon had indeed been found to exist in the property and the particular status of Radon within that home. It is clear that the Broker potential liability in this entire issue can be far-reaching if appropriate steps are not taken by the Broker to notify the appropriate parties if the Broker is aware that this situation does or may exist. You are urged to consider the implications of this issue when listing a property in an area that has been pre-identified as possibly being affected by Radon.

The contents of this memorandum were presumably passed on to the general Realtor membership who represent approximately 90% of all Buyers and Sellers in the market place. Obviously this is a statement of good intentions, designed to protect both the public and the Realtor; but what it is telling the real estate agent is simply..."don't bother to even show homes in the high risk area because chances are your client won't buy anyway after being told about the hazards of Radon." However, based upon what we now know about the incidence, measurement, effect and geography of Radon, aren't we being a little premature in targeting a defined geographic area as being a health hazard when the fact is, there appears to be NO known "safe" standards for residential dwellings. Am I not doing a disservice to my Selling clients who may have had his home tested legitimately as "safe" by telling a would-be Buyer that the home is in an area known to be a hazard? The typical Buyer would loose interest very quickly because he is more concerned with declining real estate values in the neighborhood than he is in the potential health hazard. And what about the person down the street who is about to put his home on the market and hangs is Terradex Canister in the screened porch and tells his realtor his house checked out well below the "safe" E.P.A.standard? How is the Buyer protected in this situation?

When all of the smoke is cleared, how many of the 40% of homes found to have "unsafe" levels of Radon will be proven to be as hazardous to the occupants' health than those in the Smog Belt or Acid Rain Belt, Fault Belt, or within the catastrophic limits of Three Mile Island? I do not suggest

Respectfully

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that the Radon question be minimized, I only suggest that definate standards be set to measure this natural phenominum, and that a definitive "safe" level of Radon exposure be established for residential dwellings based on real life expectations of exposure. I don't know of anyone living in the Reading Prong who is existing in their tightly sealed home 24 hours a day, 365 days a year for 50 years.

At present there are at least four different tupes of measuring devices, several confusing units of measurement and everybody and anybody is taking the measurements in a variety of different environments. Most importantly, I believe random samples should be taken throughout the country and not simply target an isolated area such as the Reading Prong. Bruce Dallas, a spokesman for the Environmental Resourses Department was quoted as saying in the July 22, 1985 issue of the Time magazine..."We're just at the tip of the ice berg in terms of impact. Radon could be anywhere." I certainly hope it is not; however, until we find out, let's not jeopardize the life savings as represented by home equity of those who just happen to live in the Reading Prong area. Hopefully, the vast majority of these homes will be proven safe from the hazards of Radon if and when we determine what "safe" is.

Sincerely,

Mark Barnola

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Mr. SCHEUER. Ms. Kathleen Varady. Oh, excuse me, Ms. Kay Jones. Who is testifying?

Ms. JONES. We are both testifying. We are splitting the time.

Mr. SCHEUER. Very good. Whoever is speaking, please pull the mike right up to you and speak right in it. Point it toward you, toward your mouth.

STATEMENTS OF MS. KAY JONES, PRESIDENT, PENNSYLVANIANS AGAINST RADON; AND MS. KATHLEEN VARADY, VICE PRESIDENT, PENNSYLVANIANS AGAINST RADON

Ms. VARADY. Mr. Chairman, members of the subcommittee: Thank you for allowing us the opportunity to speak to you in regard to the severe radon contamination problem in Pennsylvania and many other States throughout the country.

With the EPA projecting a possibility of up to 30,000 lung cancer deaths each year attributed to indoor radon contamination, we feel that a problem of this magnitude warrants an immediate response.

In a recent briefing conducted by the EPA on the radon issue, they hope to implement a 5-year program to: one, design ideas; two, study the ideas; and, three, evaluate the ideas. At the same time, they also project 200,000 radon-related lung cancer deaths will occur over the next 5 years.

To our knowledge, the EPA has been studying and dealing with man-made radon for at least 11 years. Many nongovernment experts agree with us that the time for study is over. It is now time to use the knowledge accumulated and to tackle the problem head on to start saving the lives of the families living in these unsafe homes.

The issue should not be focused on whether this is man made or naturally occurring. Unfortunately, Government bureaucracy has only acknowledged man-made radon in the past. We feel this distinction must be abolished.

The one most important fact that everyone from our State, Federal and EPA officials have overlooked is the health hazard radon poses. Nothing has changed what radon exposure will do to your lungs. The severe health hazards attributed to radon and its daughters are the same regardless of the nature of origin.

According to EPA officials, there are only two radon mitigation experts in the entire country. Both agree on the severity of our present situation but are in total disagreement as to the mitigation methods.

In instances of naturally occurring radiation, EPA officials feel it is the total responsibility of the homeowner to deal with this problem on an individual basis. Since this philosophy is in utter contradiction to man-made circumstances, we find this extremely difficult to understand.

The EPA feels that after their 5-year study is completed, methods of remediation will be designed so that the mitigation will be as simple as installing a sump pump in one's home. We are not talking about a leaky roof, a faucet that needs repair, or a backed up drain. We are dealing with an invisible force, a silent killer.

As homeowners, we all expect obstacles or setbacks from time to time, but never in our wildest imaginations can we anticipate

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facing such a major obstacle as being told that your home is not safe to live in. This, coupled with the fact that there is no one there to help, makes this experience an extremely traumatic one.

Mr. SCHEUER. Thank you. Ms. Jones.

Ms. JONES. A recent 18-home low-cost mitigation project, funded solely by the EPA, was greeted in our area with cautious optimism. Through this program, our worst fears became a reality.

It soon became apparent that there would be no easy solution to remediating our homes. We were soon to realize that methods used to mitigate one home did not necessarily prove effective in another home of a similar design. Each home became a challenge in itself for the radon mitigation expert. In two known cases, after initial methods failed to reduce the levels significantly, it became necessary to implement yet another procedure.

The most successful conclusion that can be drawn from this study is the fact that every home is unique, and remedial methods cannot be generalized as to the style or design of any given home. Many factors of which the average homeowner may be unaware must be taken into consideration before any remedial action is undertaken.

It is not inconceivable that a radon problem can be made worse by implementing the wrong procedure. We feel this is extremely unfair to add this additional burden on the homeowner who is still trying to comprehend the fact that his home has been labeled unsafe to live in.

Since the radon problem is not limited to Pennsylvania and has already surfaced in many other States, we feel a definite responsibility must be accepted by the Federal Government. Although no Federal laws specifically address indoor radon, the EPA is charged with the responsibility to protect the public from environmental sources of risk.

Although we feel this is very true, we also would like to see a more significant role carried out by the government of the affected States. This must be a combined effort put forth by both the State and Federal governments. They must do everything in their power to identify these hazardous homes and reduce their levels immediately, or many families will be forced to deal with the pain of watching a family member succumb to lung cancer.

I am concluding. High-level homes must be found before they are passed on to other families, thus continuing the deadly cycle. Because of the exposure already inflicted on our families, the pain we feel will never subside.

My own home, and Kay's home, has a radon level 100 times higher than the EPA's recommended guideline, which, by the way, at .02 still carries a 1 in 65 chance of lung cancer. Our homes are seven times higher than the level at which a uranium mine is not allowed to operate; they must be shut down at a .3 working level.

[The joint prepared statement of Ms. Jones and Ms. Varady follows:]

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Distinguished Members of Congress:

Thank you for allowing us this opportunity to speak to you in regards to the severe radon contamination problem in Pennsylvania and many other states throughout the country.

With the EPA projecting a possibility of up to 30,000 lung cancer deaths each year attributed to indoor radon contamination, we feel that a problem of this magnitude warrants an immediate response.

In a recent briefing conducted by the EPA on the radon issue, they hope to implement a five year program to: 1) design ideas, 2) study the ideas and 3) evaluate the ideas. At the same time they also project 200,000 radon-related lung cancer deaths will occur in five years. To our knowledge, the EPA has been studying and dealing with man-made radon for at least eleven years. Many non-government experts agree with us that the time for study is over...It is now time to use the knowledge accumulated and tackle the problem head-on, to start saving the lives of the families living in these unsafe homes.

The issue should not be focused on whether this is man-made or naturally occurring contamination. Unfortunately, government bureaucracy has only acknowledged man-made radon contamination. We feel this distinction must be abolished! The one most important fact that everyone from our state, federal and EPA officials have overlooked is the health hazard radon poses. Nothing has changed what radon exposure does to the lungs. The severe health hazards attributed to radon and its daughters are the same regardless of the nature of its origin.

According to EPA officials there are only two radon mitigation experts in the entire country. Both agree on the severity of our present situation but are in total disagreement as to the mitigation methods. In instances of naturally occurring radiation, some EPA officials feel it is the total responsibility of the homeowner to deal with this problem on an individual basis. Since this philosophy is in utter contradiction to man-made circumstances, we find this extremely difficult to understand! The EPA feels that after this five year study is completed that methods of remediation will be designed so that mitigation will be as simple as installing a sump-pump in ones home. We are not talking about a leaky roof, a faucet that needs repair or a backed up drain. We are dealing with an invisible force...a silent killer. As homeowners, we all expect obstacles or setbacks with repairs from time to time, but never in our wildest imaginations can we anticipate facing such a major obstacle as being told that your house is unsafe to live in. This, coupled with the fact that there is no one there to help, makes this experience an extremely traumatic one.

A recent eighteen home low-cost mitigation project, funded solely by the EPA, was greeted in our area with cautious optimism. Through this program, our worst fears became a reality. It soon became apparent that there would not be an easy solution to remediating our homes. We were soon to realize that methods used to mitigate one home did not necessarily prove effective in another home of similar design. Each home became a challenge in itself for the radon mitigation expert. In two known cases, after initial methods failed to reduce the levels significantly, it became necessary to implement yet another procedure. The most successful conclusion that can be drawn from this study is the fact that every home is unique and remedial methods can not be generalized as to the style or design of any given home. Many factors, of which the average homeowner may be unaware, must be taken into consideration before any remedial action is undertaken. It is not inconceivable that a radon problem can be made worse by

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implementing the wrong procedure. We feel this is extremely unfair to add this additional burden on the homeowner who is still trying to comprehend the fact his home has been labeled "unsafe" to live in. Since the radon problem is not limited to Pennsylvania and has already surfaced in many other states, we feel a definite responsibility must be accepted by the federal government.

Although no federal laws specifically address indoor radon, the "EPA is charged with the responsibility to protect the public from environmental sources of risk". Although we feel this is very true, we also would like to see a more significant role carried out by the government of the affected states. This must be a combined effort put forth by both the state and federal governments. They must do every*hing in their power to identify these hazardous homes and reduce their levels immediately or many families will be forced to deal with the pain of watching a family member succumb to lung cancer.

High level homes must be found before they are passed on to other families, thus continuing the deadly cycle.

Because of the exposure already inflicted on our families, the pain we feel will never subside. My own home and Kay's has a radon level 100 times higher than the safe recommended guideline. Our homes are 7 times higher than the level at which a uranium mine must be shut down. In Kay's situation, her three young children have been exposed to the equivalency of smoking 23 packs of cigarettes a day...for the past nine years. My four small children, who have been exposed during the critical infancy to ten year span, have been exposed to 22 packs of cigarettes a day...for eight years now.

No one can fully understand the guilt and anguish that we have had to bear these past nine months.

As mothers...we are devastated. As homeowners...we are angry and frustrated. As citizens...we are approaching you and begging for a solution, not only for us but for all innocent victims as well.

In conclusion, the bottom line remains- in many high radon homes sits a cancer time-bomb ready to go off!

The good news is that for most it can still be diffused and lives can be saved...The bad news is that time is running out for many of these families!

Respectfully Submitted,

Kay Jones

Kay Jones
President, P.A.R.

Kathleen Varady

Kathleen Varady
Vice-President, P.A.R.

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Mr. SCHEUER. Thank you very much, Ms. Jones. We appreciate your testimony.

Congressman Torricelli.

Mr. TORRICELLI. Thank you, Mr. Chairman.

Mr. Chairman, it is one thing for us to read that the EPA has adopted a .02 working level guideline for remedial action that you cited, which may give a 1-in-50 or may give a 1-in-60 chance of getting lung cancer. It is something else for you to live with that knowledge, knowing that not only you have that danger, but that in fact that level of danger is being sanctioned by the EPA, which is given the responsibility of protecting our citizens from environmental hazard.

I would be interested to know, Mr. and Mrs. Watras or Mr. Barnola, your own reaction to knowing that that standard has been accepted as policy in our country.

Mr. BARNOLA. Again, as a lay person, I really don't know the actual probabilities involved, but it seems like everything I read, when it gets down to a lay person's interpretation, it is relating it to numbers of cigarettes that are smoked. If you relate it to the numbers of cigarettes that are smoked, it is kind of scary.

Mr. TORRICELLI. Well, Mr. Barnola, let me put it to you this way. If there are 50 homes in your neighborhood, somebody is going to die of lung cancer. That is not the present situation; that is the goal. That is what is seen as acceptable, and that is the policy of your Government. One does not have to be an expert; he only has to be a reasoning individual to understand what that means in the lives of you and your neighbors.

My suggestion to you is that we live with that knowledge, having read it. You live with it. I wondered if we could just get a direct and flat statement from you of what it is like to be presented with that evidence, because frankly, I cannot even imagine it.

Mr. BARNOLA. Neither can I. It is scary. It is certainly not acceptable if it can be corrected.

Mr. TORRICELLI. Mr. Watras, would you like to add anything?

Mr. WATRAS. Yes, I would like to add that—how do we really know that .02 working levels is a safe level? We are using a straight-line mathematical extrapolation from uranium miners. Is a uranium mine exactly like a home? It might be, in your home, that it could be a square, a square root. You don't know. That is the thing.

Mr. TORRICELLI. Your neighbors who now find or may discover that their homes have less than a .02 level, are they living with a sense of security at this time, falsely, that in fact they are safe? It doesn't mean they are safe. It only means that their odds are somewhat better than 1 in 50 of getting lung cancer.

Mr. WATRAS. I should hope they should think that they are safe, because when you walk outside, it is probably around .02. So that is what a normal background is. So if you are talking in and around at certain times, at that particular—you know, I should hope that they would feel safe.

Mr. TORRICELLI. Mr. Watras, we were presented earlier from Senator Lautenberg and Senator Mitchell the fact that the EPA has been unable to get a $10 million commitment from the Office of

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Management and Budget to begin a program to address this problem.

I wondered if you could characterize what kinds of losses you are seeing or anticipating in property values in your own communities because of the radon problem.

Mr. WATRAS. As far as property value, I was talking to some real estate brokers in our area. They basically said that the Boyertown area did not feel any effects from this specific situation, but our general development did.

Mr. TORRICELLI. Give us a scope of the size of the property value problem, percentagewise. Would you anticipate, if you had to sell your house today as opposed to several years ago, you might lose 10 percent of its value, 5 percent of its value?

Mr. WATRAS. I think, right now, that if I tried to sell my house, even though it is labeled as being rectified, there is no way I can sell it. I don't even think I could give it away.

Mr. TORRICELLI. So you are not taking a marginal loss; your property just has no market value.

Mr. WATRAS. Absolutely none.

Mr. TORRICELLI. So, from your perspective, what we are really weighing here is the willingness of the administration to make a modest investment in a research program to answer this problem, versus the fact that up to 1 million American homes may be impacted by radon contamination, with untold millions lost in property values.

Mr. WATRAS. Exactly, yes.

Mr. TORRICELLI. And that is how you would see the issue?

Mr. WATRAS. Yes, sir.

Mr. TORRICELLI. Tell me, are people in the communities that are impacted—if you would permit me, Mr. Chairman—are there currently private measures that are being taken, people who are marketing answers or products to help people in their homes? Are such things on the market and being sold?

Mr. WATRAS. Yes.

Mr. TORRICELLI. They are?

Mr. WATRAS. One thing I would like to add is what I actually suggested. Right now, basically, you are seeing service organizations, somebody with an apparatus, somebody with a vent system, somebody with something—that means whether it is passive or mechanical.

Mr. TORRICELLI. The Wall Street Journal reported that for $700 to $1,000, many people have been able—if, in fact, they knew of the levels and the research were available—have been able to address this problem. Is that your experience?

Mr. WATRAS. I cannot really comment on that.

Mr. TORRICELLI. You cannot? Can anybody comment on whether people are in fact—yes?

Mr. WATRAS. One thing I would like to add is, you know, you mentioned a figure between, up to $1,000 or something like that. If the Federal Government would offer substantial tax credits to large corporations like DuPont—how do you know that a $50 gallon of some substance applied to a piece of concrete couldn't work just as well? We don't know that.

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Mr. TORRICELLI. Yes; you see, Mr. Watras, that has been part of—I will yield in 1 second, Mr. Chairman—that has been part, I think, of what people on this committee have been saying. No one is suggesting a massive, multibillion-dollar Government program to fix a million homes in America. But if the Government would make the relatively modest expenditure to find the levels of contamination, the locations of the contamination, and appropriate means that address the problem, our own private economy would respond. Companies would respond to the right technologies. They would market the products, and people would purchase them because of the enormous potential losses.

Is the question not of a failure of a total Government answer but of any government leadership?

Mrs. ROUKEMA. Would the gentleman yield, please?

Mr. TORRICELLI. I would be glad to, although I have no time. [Laughter.]

Mrs. ROUKEMA. I don't know about the chairman. Would the chairman——

Mr. TORRICELLI. I will yield the chairman's time. [Laughter.]

Mr. SCHEUER. Yes, let's do that. I will yield, but from now on, I am going to run a very tight ship.

Mrs. ROUKEMA. It is relevant to a very important point that Mr. Torricelli has made.

To the credit of the State of New Jersey, we do have a hotline, a New Jersey hotline on this subject, and there is, in fact, at least one private enterprise that I know. For a modest investment of $50, there is a kit. And there are other ways of going about helping families detect and evaluate the radon danger.

But the gentleman from New Jersey makes an important and valid point.

Mr. TORRICELLI. I thank my colleague.

Mr. Chairman, I thank you, and I think it is only appropriate to these people to really offer some apologies, Mr. Chairman. You know, the American people don't ask for a lot from their Government. The one thing they ask is they at least be able to live safely in their homes, and in that expectation, you have been denied its fulfillment.

Mr. SCHEUER. You have especially been denied the knowledge to do it yourself, and to me, that is inexcusable.

Mr. WATRAS. Yes.

Mr. SCHEUER. Congresswoman Claudine Schneider.

Mrs. SCHNEIDER. Thank you.

I just have a very brief question of Mr. Watras. Have you been able to define what is the source of the radon pollution pretty well?

Mr. WATRAS. Yes, ma'am.

Mrs. SCHNEIDER. Could you tell me?

Mr. WATRAS. The source of our radon problem was approximately 12 to 18 inches under the topsoil in which there was pure uranium ore encountered.

Mrs. SCHNEIDER. And so the understanding is that that ore penetrated throughout the entire house, because the levels that you gave were for your basement, for your family room, other parts, and it is believed that it is through that process that——

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Mr. WATRAS. It is through the natural decay of uranium ore. Yes, ma'am.

Mrs. SCHNEIDER. I have no further questions, only because I found the witnesses' testimony to be so comprehensive that you covered so many of the points that I was interested in. Thank you for your very fine testimony today.

Mr. SCHEUER. Congressman Gus Yatron, from the problem area of Pennsylvania.

Mr. YATRON. Thank you, Mr. Chairman.

I just have one question. I just want to make one comment to Mr. Barnola. I understand your concerns about the effect the identification of the prong has on property values within it, but have you thought about what your legal responsibilities might be if you were the agent involved in selling a home that is contaminated by radon to an unknown buyer.

Mr. BARNOLA. Absolutely. That is of utmost concern to all of us. We are also concerned about our obligation to our fiduciary, who is the seller, who may have had a test done on his home which has shown it to be clear of high radon levels. By just the mere mention of the fact that they are in the Lehigh Valley radon belt would scare any would-be buyer away, and I am concerned about the effects of that legal situation, also.

Mr. YATRON. Thank you.

Thank you, Mr. Chairman.

Mr. SCHEUER. Congressman Don Ritter.

Mr. RITTER. Thank you, Mr. Chairman, and I thank all of you for your excellent testimony.

I would kind of like to clear the air on just what governments are doing and when they are required to gear up and take action.

It seems to me that ever since this problem came to the forefront with the Watras home—and I and Congressman Edgar and Congressman Yatron have been fairly active—it seems to me that—our request to EPA to begin a major study on this area—it seems to me that there has been some response.

Now, the problem that we face is one of—I think it was well reflected by Mr. Watras' comments. What do these levels mean? Right now, we are extrapolating data from the uranium mine situation. We have no epidemiological data, which means at this time—and maybe the science expert panel can help us—but right now, we are not completely sure of the impact of radon on people living in these homes at these various levels.

If .02 working levels are taken as gospel at this stage, we are going to have to move out of the Lehigh Valley and the Reading Prong, to a fairly large extent. I guess my question is, do we move immediately to evacuate all homes or to remediate all homes, or do we seek the kind of risk assessment, hazard assessment, and epidemiology that allows us to target some resources in a way that is rational and logical without totally disrupting the Reading area congressional district, the Lehigh Valley congressional district, and other areas, not just in Pennsylvania?

That is a rhetorical question, but, Mr. Watras, could you take a crack at that?

Mr. WATRAS. Yes, definitely.

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You are right, we really don't know if .02 is an acceptable level. It could be greater. It could be a square; it could be a cube. You are saying right now, should we panic, should we move the entire Lehigh Valley out of their homes? Why don't we think of it this way? I would rather be safe than sorry. I would rather do everything—if I was part of the government, I would rather do everything possible to save one life, because life is very, very important.

So what I feel is that we have to almost shotgun the effect. We have to do the epidemiological studies. I know you are probably not going to get that back for years and years and years of study, but we have to be safe. We cannot put human lives on premise.

Mr. RITTER. I agree, but at what level are we going to remediate, given the fact that the overall resources could run—what was the figure you mentioned, Mr. Barnola, in terms of housing stock that could be at stake here?

Mr. BARNOLA. I don't think I mentioned a figure. I cannot help you with that.

Mr. RITTER. But it could run into hundreds of millions of dollars.

Mr. WATRAS. Yes.

Mr. RITTER. It could run higher.

I noticed that the Governor of Pennsylvania, Dick Thornburgh, announced today the Nation's first homeowner assistance program to aid in eliminating radon gas from homes through a $3 million low-interest loan program that will help residents in Berks, Lehigh, Northampton, and Bucks. I guess what they will do is just take the highest readings first and work their way down.

Three million dollars, if you are looking at $500 on average per home, or even, say, $1,000 on average, is 3,000 homes. Is that a step in the right direction?

We have a tax credit bill, by the way, which would allow people to work on this on their own. We are also looking at a low-interest loan program here in the Federal Government.

Mr. WATRAS. One thing the Government could do that would not bankrupt this country is basically, say, a modest tax credit to you, Mr. DuPont, to come up with a $50 gallon of whatever to do that.

Mr. RITTER. But that could take as long as an epidemiological study.

Mr. WATRAS. I don't believe so.

Mr. SCHEUER. The time of the witness has expired.

Mr. RITTER. The witness.

Mr. SCHEUER. The time of my colleague has expired.

Congressman Jim Courter of New Jersey.

Mr. COURTER. Thank you, Mr. Chairman.

I have just a couple of questions, very quickly. All of you live and have had personal problems with respect to your homes. You talked about the personal trauma; you talked about the potential loss in property value.

Have you been inundated with private individuals or private corporations or small companies saying, "Let me in your home and I'll fit it at a modest fee"? Is that an experience? Ms. Varady, would you respond to that, or Ms. Jones?

Ms. VARADY. Kay and I both have been. We usually have dealt with them together or through the group. We have formed a group in the Boyertown area in Berks County. It is the Pennsylvanians

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Against Radon. We have more or less screened them and, with the help of the DER, we have called them up and given them the name of the person that had been in touch with us and asked them if they had spoken to them, more or less to screen them that way.

Mr. COURTER. So this is a self-screening——

Ms. VARADY. Some have been reputable and some have been really fly-by-nights.

Mr. COURTER. Some fly-by-nights, some reputable?

Ms. VARADY. Yes.

Mr. COURTER. And you have some sort of a self-screening process that you have gotten together to do?

Ms. VARADY. Right. We have been very fortunate with the DER that they have worked with us on this.

Mr. COURTER. Have any of them, after the screening process is completed, been invited to analyze the radon levels in homes?

Ms. VARADY. Yes.

Mr. COURTER. And have any of them followed through with making recommendations for the alleviation of the problem, and if so, how much did they quote you on monitoring and alleviation?

Ms. VARADY. Right now, we have a project going on with Nutone. It is for the air-to-air heat exchangers. They are doing a 10-home study. They are having the homes tested before the installation of the air-to-air exchanger, installing the air-to-air heat exchanger with it running, and then keeping the house closed for 2 days after installation, and then they are retesting the home.

They have done three homes so far. Two of them have been very successful. They were at a .1 working level or lower, and they have taken them to far below the .02.

In one, the level was one whole working level. They did not get that home down to safe levels, but we more or less expected this because, with the research that we have done, the air-to-air heat exchanger, at a greater radon concentration in the home, you would have to do another step to remediation to accompany that.

Mr. COURTER. Mr. Chairman, someone else will probably have another question before we vote. I am finished. Thank you.

Mr. SCHEUER. We have finished the questions.

Mr. COURTER. All right, fine.

Mr. SCHEUER. We have finished the questions for this panel, and we are finished with the panel. We thank you again very much for all of the trouble and effort you went to in coming from your homes in Pennsylvania and elsewhere to Washington to enlighten us, and you certainly have done that.

Thank you very much.

All right, we are going to suspend for about 15 minutes, and then we will start in with the second panel.

[Recess taken.]

Mr. SCHEUER. The hearing will resume.

We have on this panel Mr. Sheldon Meyers, Director of the Office of Radiation Programs of EPA; Mr. John Millhone, Director of the Office of Buildings and Community Systems, DOE; Mr. John Skinner, Office of Environmental Engineering and Technology, EPA; and Hon. Nicholas DeBenedictis, secretary of the Pennsylvania Department of Environmental Resources.

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All present and accounted for? All right, we will then proceed. Incidentally, I want to inform you all that your testimony will be printed in full in the record at the point at which you speak. We are on a 5-minute rule. It is now 4:30, and we still have another panel after this one, so I am going to adhere very strictly to the 5-minute rule and ask you, when the bell goes off, to finish your sentence—no more.

Mr. Skinner, please proceed.

Mr. MEYERS. I will be going first.

Mr. SCHEUER. Dr. Meyers, please proceed.

STATEMENT OF SHELDON MEYERS, ACTING DIRECTOR, OFFICE OF RADIATION PROGRAMS, U.S. ENVIRONMENTAL PROTECTION AGENCY, ACCOMPANIED BY MR. JOHN SKINNER, DIRECTOR, OFFICE OF ENVIRONMENTAL ENGINEERING AND TECHNOLOGY, U.S. ENVIRONMENTAL PROTECTION AGENCY

Mr. MEYERS. As you requested—and assuming that you will do as you said, which is to put the whole testimony in the record—with your permission, I will just summarize it, then.

Mr. SCHEUER. Please do.

Mr. MEYERS. I am going to discuss the state of our knowledge concerning the risks posed by exposure to radon in residences and possible mitigation strategies to reduce the risks, and review present and planned Federal efforts.

I wish to emphasize at the outset that EPA's activities in radon are a cooperative effort with other Federal agencies who are active in the radon area, including the Department of Energy, the Centers for Disease Control, the Department of Housing and Urban Development, as well as the affected States such as Pennsylvania.

As you know, radon is a radioactive gas, and as it decays, it produces decay products that are also radioactive. Some of these products, like radon, emit a type of radiation known as alpha particles. Alpha particles do not travel very far and cannot penetrate even through paper.

However, if they are inside the body, they can be very damaging to internal organs such as the lungs and can lead to the formation of cancer cells. Inhaling radon decay products over a long period of time increases the risk of developing cancer.

I want to briefly discuss our past and current activities. Over the past 15 years, EPA has developed a range of expertise and interests in various aspects of indoor radon. Many activities resulted from programs to assist States with specific problems of elevated indoor radon levels in such areas as Colorado, Florida, New York, and most recently in Pennsylvania.

Other work was performed in support of rulemaking under the Clean Air Act, the Uranium Mill Tailings Act, and the Safe Drinking Water Act. The Agency has also begun a few projects on indoor radon, with a portion of the funds provided by Congress in fiscal years 1984 and 1985 for work on indoor air quality.

Let me just quickly run down the kind of assistance we have been providing: first, to the States. Starting in early 1970, EPA has responded to States' requests for technical assistance to investigate indoor radon exposure due to uranium mill tailings, phosphate

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ores, and other wastes, radium wastes, and natural resources. This assistance has included technical guidance, remediation projects, and measurement programs.

With regard to mitigation methods: in response to the need to demonstrate control techniques and provide short-term mitigation of elevated levels of radon, the agency has evaluated both preventive construction techniques for new structures and remedial methods for contaminated structures.

Health effects research: In support of EPA rulemaking activities, the Agency has invested a great deal of effort in estimating the risk of cancer associated with exposure to radon. Past agency funding for epidemiological and radiodosimetry studies have contributed greatly to the current state-of-the-art in risk assessment.

Within a month, EPA will survey and review the adequacy of existing epidemiological studies relating radon exposure to the incidence of cancer in humans, determine whether National Cancer Institute surveys identify the Reading Prong, or other geographical areas with suspected elevated radon levels, as hot spots for lung cancer or other tumors, and if it is determined no appropriate epidemiological study of the Reading Prong exists, we will begin designing an epidemiological study to test the association of radon exposure with tumor incidence in the Reading Prong.

In regard to measurement methods: the measurement of radon and its decay products has long been an area of EPA involvement. Several important measurement methods that are currently in use were developed primarily with EPA support and guidance.

The Environmental Protection Agency is currently studying several alternatives for investigating and resolving the major issues of indoor radon problems. These efforts are focused on: one, an exposure and risk assessment; two, mitigation of exposure in existing structures; and, three, prevention of exposure in future construction. We anticipate key decisions will be made soon to determine the appropriate role of EPA in dealing with this environmental hazard.

Now, with regard to the Reading Prong: regardless of our uncertainty associated with the distribution of radon nationally, existing evidence strongly indicates that the health risks from exposure to indoor radon are very significant in portions of the Reading Prong, a geological formation, as you have heard, rich in uranium ores, which reaches principally through sections of Pennsylvania, New York, and New Jersey.

I just want to quickly mention that we have a mitigation project in our Office of Research and Development, and the objective of the radon mitigation project is to develop and demonstrate low-cost residential radon mitigation techniques applicable to all home structure types in all regions of the country. Mitigation measures for existing homes are receiving first priority, since families are being exposed to radon in existing homes now.

Last, I just want to mention that we have been working with other Federal agencies, and the coordination there, we believe is very good. There is active interest on the part of other Federal agencies to assist in evaluation and resolution of radon problems, et cetera.

Mr. SCHEUER. Go ahead, finish the sentence.

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Mr. MEYERS. The Committee on Indoor Air Quality, which is comprised of 16 Federal agencies, has a special work group co-chaired by EPA and DOE to share information, coordinate plans, and develop study needs on this problem.

The Conference of Radiation Control Program Directors, which is composed of representatives from all 50 States, has been working closely with EPA to facilitate a close Federal-State working relationship in defining the issues and priorities in assessing the indoor radon problem.

[The prepared statement of Mr. Meyers follows:]

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STATEMENT OF SHELDON MEYERS

Mr. Chairman, my name is Sheldon Meyers and since August 1984 I have been Acting Director of the Office of Radiation Programs in the U.S. Environmental Protection Agency. I appreciate your invitation to appear today to testify at these special hearings on Radon. I am accompanied by John Skinner, Director of our Office of Environmental Engineering and Technology.

As you have requested, I am prepared first to present information on the state of knowledge concerning the risks posed by exposure to radon in residences and possible mitigation strategies to reduce the risk; review present and planned Federal and State efforts, particularly in Pennsylvania, with respect to radon contamination. I wish to emphasize that EPA's activities in radon are a cooperative effort with other Federal agencies who are active in the radon area, including the Department of Energy, the Centers for Disease Control, the Department of Housing and Urban Development, and others.

BACKGROUND

I would like to begin by briefly discussing what radon is for those here who might not be familiar with the subject. Radon is a radioactive gas formed by decay of radium which is formed in turn by the decay of uranium that is naturally present in rocks and soil in many parts of the United States. Since radium and uranium are common elements in rock and soil, radon is being constantly generated everywhere. However, normal

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concentrations of radium in soil and rock are very low. Because radon is a gas and not chemically bound or attracted to other materials, it moves easily through very small spaces such as those between soil and rock particles. Radon 222, produced by the decay of radium 226, is the type predominantly found indoors.

When radon undergoes radioactive breakdown, it produces decay products (sometimes called radon progeny or radon daughters) that are also radioactive. Some of these products, like radon, emit a type of radiation known as alpha particles. Alpha particles do not travel very far and cannot penetrate even through thick paper. However, if they are present inside the body they can be very damaging to internal organs such as the lungs and can lead to the formation of cancerous cells.

Inhaling radon decay products over a long period of time increases the risk of developing lung cancer. These decay products tend to adhere to dust particles and other surfaces which, when inhaled, may stick to the airways of lungs.

While the concentration of radon in the outdoor environment does not usually pose a significant health hazard, the situation indoors is much different. Radon will concentrate in indoor environments because of the limited exchange rate between indoor and outdoor air (typically a few air changes per hour or less). The rate of entry of radon into a structure and the air exchange rate influence the radon concentration inside the structure. A decrease in the ventilation rate in a structure causes an

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increase in the radon and decay product concentrations. Once inside, the radon tends to remain inside buildings because most structures today are designed to keep heated or cooled air from escaping to the outside.

Radon from groundwater and building materials are not major sources of exposure for the general population, but can be significant sources in some areas of the country. The most significant pathway of radon entry is migration from soil into the indoors through openings such as cracks, drains, cinder block walls and utility openings in the basement or foundation slab. The rate of radon entry from the soil is affected by many factors, including radium content, porosity, moisture level of the soil, house construction, and meteorological conditions. The variability of these factors contributes to the wide distribution of average radon concentrations that have been observed in homes in the U.S.

Radon concentration in air is generally measured in units called picocuries per liter (pCi/l). This tells one how many atoms of radon are decaying in a liter volume of air. Radon concentration in outside air varies around the country but is generally less than 1 pCi/l of air. Concentrations of radon decay products are measured in a unit called the Working Level (WL). This unit was developed to document the exposure of underground uranium miners, hence its name. One Working Level is approximately equal to 100 pCi/l of radon and an equivalent amount of its short half-life decay products. Cumulative exposure to the decay products is measured in working level months (WLM). Exposure at one working level for 173 hours (calculated as a working month) is equivalent to one WLM.

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HEALTH RISKS

Improvement in the health risk estimates depended largely on obtaining better data on the national distribution of indoor radon levels and refining the unit health risk values. Our information on the health risks from exposure to radon comes primarily from epidemiology studies of underground miners throughout the world. Statistically significant increased risk of lung cancer in miners has been observed for exposures around 80 to 100 WLM. Data from U.S. miners who experience large increases in lung cancer rates showed that their highest exposures were around 8000 to 10,000 WLM. In some homes measured, exposure rates are over several hundred WLM per year. Lifetime exposures at these rates would lead to cumulative exposures of well over 10,000 WLM, considerably higher than exposure to the greatest exposed miners. Current estimates suggest that the risk of lung cancer is doubled by a cumulative exposure of 20-100 working level months. Currently, the average lifetime risk of lung cancer in the United States is about 3 to 4 in 100. Considering the high levels observed in some homes, a person living in those homes could have their lifetime risk of lung cancer increased to well over one chance in two. This means that these people might have a greater than 50-50 chance of getting lung cancer due to the radon. Several radiation protection groups have estimated the number of annual lung cancer deaths attributable to indoor radon. Since we do not know the true distribution of exposures, these estimates are based on lifetime exposure (at 75% occupancy) to the average indoor level of radon decay products (crudely estimated to be about 0.004 WL), the number of dwellings and residents in

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the United States, and values for lung cancer risk coefficients. The resulting estimate of aggregate health effects over all exposure levels ranges from about 5000 to 20,000 lung cancer deaths per year. The difference between the upper and lower values is primarily associated with the use of different unit risk coefficients by various investigators.

PAST AND CURRENT ACTIVITIES

Over the past fifteen years, EPA has developed a range of expertise and interests in various aspects of the indoor radon issue. Many activities resulted from programs to assist States with specific problem of elevated indoor radon levels, in such areas as Colorado, Florida, New Jersey, and most recently Pennsylvania. Other work was performed to support rulemakings under the Clean Air Act, Uranium Mill Tailings Radiation Control Act, and the Safe Drinking Water Act. The Agency has also begun a few projects on indoor radon with a portion of the funds provided by Congress in FY 1984 and FY 1985 for work on indoor air qualiity. Major areas of the Agency's past and current efforts follow:

1. Assistance to States:

Starting in the early 1970's, EPA has responded to States' requests for technical assistance to investigate indoor radon exposure due to uranium mill tailings, phosphate ores and wastes, radium wastes, and natural resources. This assistance has included technical guidance, remediation projects, and measurement programs.

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Current assistance efforts include:

a. Technical assistance, including equipment loans and survey teams and sample analysis;

b. Participation in both public meetings and workshops for State radiation personnel; and

c. Demonstration of low cost mitigation techniques.

2. Mitigation Methods:

In response to the need to demonstrate control techniques and provide short-term mitigation of elevated radon levels, the Agency has evaluated both preventive construction techniques for new structures and remedial methods for contaminated structures. Current activities include:

a. Demonstration of low-cost mitigation techniques in homes;

b. Evaluation of air cleaning methods;

c. Technical guidance on new house designs on Florida phosphate lands;

d. Pilot demonstration of radon removal from water; and

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a. Survey of existing information on cost-effectiveness of alternative mitigation techniques.

3. Health Effect Research:

In support of EPA rulemaking activities, the Agency has invested a great deal of effort in estimating the risks of cancer associated with exposure to radon. Past Agency funding for epidemiology and radiationdosimetry have contributed greatly to the current state of the art in risk assessment. Current activities sponsored by EPA include:

a. Sponsoring a study by the National Academy of Sciences review of risk due to exposure to alpha radiation;

b. Initiating an epidemiology study on the association between radon in drinking water and lung cancer with the Maine Medical Center. (In this case control epidemiology study, between 600-800 cases of lung cancer will be investigated in the States of Maine and New Hampshire and will be compared with 1200 controls.);

c. Development of models for the uptake and dosimetry of ingested radon; and

d. Coordinating planned and ongoing epidemiological studies involving radon among Federal and State agencies.

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In addition, within a month EPA will survey and review the adequacy of the existing epidemiological studies relating radon exposure to the incidence of cancer in humans; determine whether National Cancer Institute surveys ("cancer maps") identify the Reading Prong, or other geographical areas with suspected elevated radon levels, as "hot spots" for lung cancer or other tumors; and if it is determined no appropriate epidemiological study of the Reading Prong exists, we will begin designing an epidemiological study to test the association of radon exposure with tumor incidence in the Reading Prong.

4. Measurement Methods:

The measurement of radon and its decay products has long been an area of EPA involvement. Several important measurement methods that are currently in use were developed primarily with EPA support and guidance. Current and planned activities are:

a. Development of measurement protocols;

b. Development of calibration standards for radon flux measurement for soil;

c. Quality assurance programs for radon;

d. Radon emission factors from soil and water; and

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e. Instrument calibration.

5. Policy Development:

Development of policy perspectives and risk management programs have been another area of EPA involvement in this issue. Recent and current activites include:

a. Standards for clean up of uranium mill tailing contamination;

b. Guidance on the State of Florida's standards for indoor radon exposure from phosphate lands; and

c. Analysis of voluntary responses of Maine homeowners to information on risk and mitigation alternatives;

The Environmental Protection Agency is currently studying several alternatives for investigating and resolving the major issues of the indoor radon problem. These efforts are are focused on: 1) an exposure and risk assessment, 2) mitigation of exposure in existing structures, and 3) prevention of exposure in future construction. We anticipate key decisions will soon determine the appropriate role of EPA in dealing with this enviromental hazard.

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READING PRONG

Regardless of our uncertainty associated with the distribution of radon nationally, existing evidence strongly indicates that the health risks from exposure to indoor radon are very significant in the Reading Prong, a geological formation rich in uranium ores which reaches principally through sections of Pennsylvania, New Jersey, and New York. As most persons in this audience know, extremely elevated concentrations of radon were discovered last winter in houses in the Reading Prong in Pennsylvania.

We understand fully the concern of residents in the Reading Prong area who realize that with the approach of the heating season their problem will be exacerbated. We have been studying various options that we can implement in the short term to assist these homeowners. These options include both remedial and nonremedial action activities.

More than 2800 homes have been surveyed in and around Boyertown, Pennsylvania, by the State, with some limited assistance by EPA's Office of Radiation Programs (ORP). Of the homes surveyed more than ten percent have radon decay product concentrations of over 0.1 working level. As the survey numbers have increased, the percentage of homes in each concentration range have stayed relatively constant. I believe that the representatives from the State of Pennsylvania will discuss this data in more detail.

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The Agency's activities, to date, in assisting the State of Pennsylvania have been predominantly in providing measurement and sample analysis quality assurance checks on the State's analysis, and demonstrating certain mitigation methods. EPA's Office of Radiation Programs has sent, on two occasions, measurement teams to assist the State in surveying homes. These teams augmented the State's available manpower and provided expertise in measurement techniques and data interpretation. In addition, EPA has provided the State with measurement equipment and has analyzed several thousand air and water samples for the State.

EPA has conducted a training program for State personnel to provide information to them on radon, including how to estimate risks from exposure to radon, and various measurement techniques. This course was held in Harrisburg and was attended by representatives of several States. Due to the very positive response we had to this effort, EPA is planning to conduct similar workshops in several other States in the future.

At this time, the States of Pennsylvania, New Jersey and New York are in the process of designing and conducting surveys of radon levels. The Pennsylvania survey will include the 22,000 homes in the Reading Prong; the New Jersey and New York surveys will include relatively extensive measurement of homes built on the Prong. These surveys are expected to be completed in one to two years. Preliminary results may be useful in characterizing the full extent of the problem of elevated radon concentrations in homes built on the Prong.

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MITIGATION PROJECT

EPA's Office of Research and Development has sponsored an eighteen home demonstration project in the Reading Prong area.

The objective of the radon mitigation project is to develop and demonstrate low-cost residential radon mitigation techniques, applicable to all home substructure types in all regions of the country. Mitigation measures for existing homes are receiving first priority, since families are being exposed to radon in existing homes now. Measures to assure low radon levels in new homes will also be addressed. These techniques, in addition to being low in cost, are intended to be reliable, durable, low-maintenance, and amenable to do-it-yourself installation. A technology transfer/technical assistance effort (including homeowner- and builder-oriented manuals) is planned that will provide information to help homeowners have the techniques installed on their own.

The initial phases of field testing has just been completed. In this phase, mitigation measures were installed on 18 homes in the Reading Prong region of eastern Pennsylvania. Short-term (2-day) monitoring of performance has been completed, with longer-term (2-month) monitoring scheduled for this winter. Homes typical of the region were selected for testing; all had basements with concrete floors and concrete block walls. The measures tested in this first phase all included forced ventilation, using fans to suck the radon-containing soil gas away from the home; forced ventilation was selected for this initial testing because it was

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judged to offer the greatest potential for achieving the very high radon reductions (98-99+%) needed in some Prong homes. The measures tested included ventilation of: the voids within the block walls of the basement; the aggregate beneath the concrete slab; or the drain tiles near the footings.

The short-term results are very encouraging. In four homes which initially had very high radon levels (up to 7.4 Working Levels), levels were reduced to 0.03 WL or less by the application of refined versions of these mitigation measures, representing reductions of 97 to 99+%. Results from these four homes are:

Home	Mitigation Measure	Working Level	
		Before	After
1	Wall vent plus sub-slab vent	4.2-7.4	0.005-0.02
2	Wall vent plus sub-slab vent	1.2-2.4	0.01-0.03
3	Wall vent only	0.3-0.8	0.01-0.02
4	Drain tile vent	0.7-1.6	0.01-0.02

These post-mitigation levels compare well with the remedial action level of 0.02 WL for homes built on uranium mill tailings, suggesting that even worst-case homes in the Prong might be reduced to low levels using these techniques. Most of the other homes tested achieved average percentage reductions between 80 and 97%, somewhat less than the above four homes; in these remaining homes, initial levels ranging from 0.05 to 2.5 WL were reduced to 0.005 to 0.1 WL. These remaining homes did not achieve reductions as high as the above four either because: a) the home was tested early in the series, before the refinements in the mitigation

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technique were implemented; or b) the home's initial radon level was relatively less elevated to begin with. In only two homes were average reductions less than 80% achieved; these two homes were not amenable to the specific technique installed, but, with current knowledge, could be mitigated using one of the other techniques.

Before the above results can confidently be extended to other concrete block basement homes, EPA needs: a) tests of the refined techniques on a larger number of homes; b) long-term monitoring (2-month), preferably with measurements over several years; and c) monitoring in the winter, when the natural stack effect in the home will give the mitigation technique its most severe test. If performance does degrade during the winter due to the stack effect, it should be possible to compensate for this effect by use of a larger fan. Although some of these techniques are applicable only to concrete block basement homes (e.g., wall ventilation), some (such as drain tile ventilation) would also be applicable to some homes of other substructure types.

Preliminary cost estimates for these techniques vary, depending upon assumptions. If the technique were being installed now (with the relatively limited number of demonstration homes currently available for reference), and if an expert consultant were thus felt to be necessary to oversee the building contractor making the repairs, then installation costs could be as high as $5,000 to $10,000 (with the higher cost including a guarantee to reduce radon levels to 0.02 WL). Costs should drop, however, after homeowners and building contractors become

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sufficiently familiar with the the techniques, so that expert consultants are no longer necessary and so that installation is consistently performed properly the first time. Under these conditions, installation costs could ultimately fall to approximately $1,000 to $6,000 for installation by a builder (depending upon the specific technique to be installed, and depending upon how amenable the specific home is to that technique). If the homeowner installs the technique himself, so that the major cost is just that of materials, the ultimate capital costs of these techniques could be as low as $300 to $600. For techniques that require operation of a fan, operating costs are estimated to be about $140 per year.

A homeowner- and builder-oriented manual will be prepared by Spring 1986, based upon the results from the first 18 homes (including the 2-month winter data). This manual is intended to provide information that should aid homeowners in having these techniques installed on their own. Additional mitigation testing is being considered for homes in the Reading Prong and elsewhere, in order to test the refined techniques in a larger number of homes, to test further refinements and new techniques, to test additional home substructure types, and to test techniques for new homes. This additional mitigation testing, part of which could begin in early 1986, will address some totally passive approaches as well as active ventilation techniques. Also being considered are multi-year monitoring of technique performance in some homes, and technical assistance efforts to assist in the effective implementation of the mitigation measures. An expansion of this mitigation R&D program is currently under consideration.

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FEDERAL COORDINATION

There is active interest on the part of other Federal agencies to assist in the evaluation and resolution of the the problem of elevated radon concentrations in homes. These different agency concerns have led to the formation of several forums for discussing and coordinating activities related to the indoor radon problem. The Committee on Indoor Air Quality (CIAQ), which is comprised of sixteen Federal agencies, has a special workgroup, co-chaired by EPA and DOE, to share information, coordinate plans, and develop study needs on this problem. The Conference of Radiation Control Program Directors, which is composed of representatives from all fifty States, has been working with EPA to facilitate a close Federal-State working relationship in defining the issues and priorities in assessing the indoor radon problem. In addition, The Committee on Interagency Radiation Research and Policy Coordination (CIRRPC), under the Office of Science and Technology Policy (OSTP), is also examing the radon issue through its recently established Radon Subpanel. This groups efforts are designed to ensure that all important radon science issues are being addressed by the appropriate agencies in the Federal Government.

There is currently a high degree of coordination among the various Federal and State activities on indoor radon. Many projects in the Federal sector have benefited from the close working relationships that have developed among staff representing the different agencies and groups. In particular, EPA and DOE are succeeding in efforts to jointly

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support projects, actively share new information, plan and assign priorities for new projects, and to prepare consistent and complete responses to requests for information. Other groups, such as HUD, the U.S. Geological Survey, the National Bureau of Standards, the Centers for Disease Control, and several States are also active in various interagency efforts on indoor radon.

This concludes my prepared statement, Mr. Chairman, and we will be pleased to answer any questions you may have.

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Mr. SCHEUER. Thank you very much, Dr. Meyers.

Mr. Millhone, we are adhering strictly to the 5-minute rule, and I would ask you, when the bell goes off, finish your sentence.

STATEMENT OF JOHN P. MILLHONE, DIRECTOR, OFFICE OF BUILDINGS AND COMMUNITY SYSTEMS, OFFICE OF CONSERVATION AND RENEWABLE ENERGY, U.S. DEPARTMENT OF ENERGY, ACCOMPANIED BY DR. J.W. THIESSEN, OFFICE OF HEALTH AND ENVIRONMENTAL RESEARCH, DOE

Mr. MILLHONE. Thank you very much, Mr. Chairman. It is a pleasure to be here.

I would like to introduce Dr. J.W. Thiessen, who is with the Office of Health and Environmental Research at the Department of Energy as well.

The work that is done at the Department of Energy is done by three groups. The conservation area is interested in looking at how radon would be affected by their efforts to save energy through more efficient buildings.

The Office of Health and Environment Research has its source in the old Atomic Energy Commission, and it is concerned about the biological effects of radiation.

In addition, there is the Bonneville Power Administration, which is responsible for the implementation of energy conservation programs in the Pacific Northwest.

In this context, DOE's research on radon focuses on several subjects including source characterization, measurement methods, field studies, health effects, and control measures.

As far as source characterization, the work of DOE, which goes back to 1977, has shown that the primary source of radon is soil gas and that the primary method by which it enters the building is a result of pressure-driven flow from the area surrounding the building.

Regarding measurement methods, DOE has emphasized quality assurance, instrument development, and measurement control. For example, we have developed a portable passive radon monitor used to determine the amount of radon available.

In the area of field studies, DOE has sponsored a number of monitoring activities in the form of field studies. The collection of these field study results and those of other research projects has been shown in a distribution curve that is part of my testimony. The curve, based on measurements in 552 houses located in areas that were not considered high radon spots, indicates that perhaps 2 percent of the U.S. houses, or over 1 million homes, are at the action level for remedial action, which is 8 picocuries per liter of radon.

We have also done some work in evaluating several strategies for reducing radon levels in buildings. The areas in which we have done this mitigation work involve air-to-air heat exchangers, filtration, and other source control techniques.

Finally, a major objective of the Department is to synthesize its research results into a form that is accessible and usable by the public and by private industry, and to also disseminate this information to State and local governments.

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As far as the Department's work in the Reading Prong geological formation area, our work in that area has been to do aerial radiation surveillance, some mobile gamma scanning, some measurements of indoor radon concentrations in homes, and the distribution of consumer information. The aerial and mobile gamma scanning work was done at the request of the Pennsylvania Department of Environmental Resources, and the information has been turned over to that agency.

While much progress has been made in improving our understanding of radon and its effect on health, additional work needs to be done in several areas. These concern the development of additional data on radon concentrations and anomalies, the assessment of the health risks associated with these findings, and the effects of energy conservation activities and various mitigation strategies on indoor radon levels.

Hence, in the President's budget, there is support for the addressing of these special projects, with emphasis on studying radon transport mechanisms into buildings, modeling the behavior of radon progeny within buildings, conducting animal and epidemiological lung dose studies, combining radon exposure data and the results of health effects studies to assess both population and individual risk of indoor radon, and developing energy efficient control techniques to reduce radon and radon progeny concentrations.

We are all cooperating with international bodies to ensure that there is quality assurance for the radon indoor measurements.

This concludes my prepared remarks. Thanks again for the opportunity to testify here.

[The prepared statement of Mr. Millhone follows:]

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STATEMENT OF JOHN P. MILLHONE

Mr. Chairman and Members of the Committee, I appreciate the opportunity to appear before you today to provide information on the Department of Energy's research in the area of indoor air quality relating to the assessment and mitigation of radon gas.

CURRENT STATE OF KNOWLEDGE

Radon is a naturally occurring gas produced by the radioactive decay of the element radium. Since radium is present throughout the earth's crust and can become dissolved in water, radon is found virtually everywhere. Outdoor air concentrations of radon originating in the soil are low due to dilution with outdoor air. In contrast, indoor concentrations are typically 2-10 times higher than outdoors. Radon itself decays and produces a series of short-lived radioactive products (called radon progeny), which when inhaled may irradiate cells in the respiratory tract. This decay chain continues until the product becomes a stable form of lead.

Studies show that exposure of uranium and other underground miners to high levels of radon progeny increases their risk of lung cancer. The evidence is not conclusive on human exposures. However, animal exposure studies conducted by DOE have shown that lower levels of exposure to radon progeny produce a proportionately reduced level of health risk.

Energy conservation efforts which reduce ventilation rates may affect radon levels and consequently exposure to radon in buildings. The amount of radon found in U.S. residences is highly variable, and radon concentrations from one house to another may vary by several hundred times.

The current state of knowledge about indoor radon concentrations is spotty and incomplete in several areas of scientific investigation: geologic distribution, building entry mechanisms, epidemiology, and others.

Entry and removal processes for radon can be complex. Entry is complicated by several factors including the fact that radon emanates from several sources (predominantly soil, but also water and building materials) and can enter a building at different rates throughout the day and year. The radon removal rate depends on the ventilation rate, but can also be affected by filtration

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and air circulation patterns. Radon concentration distributions throughout the United States are not homogeneous. Certain areas of the country have much higher concentrations than others. Additionally, the health effects of exposure to low levels of radon and its progeny are not well understood.

DOE RESEARCH ACTIVITIES

The Department of Energy (DOE) has had activities on the subject of indoor radon since 1977. Three offices within DOE conduct indoor radon research. These are: the Office of Buildings and Community Systems of Conservation and Renewable Energy; the Office of Health and Environmental Research of the Office of Energy Research; and the Bonneville Power Administration.

The objectives of this research are to: (1) understand the mechanisms and determine the rates at which radon enters buildings; (2) develop predictive techniques to identify regions of the country and building characteristics which would likely result in high indoor radon concentrations; (3) assess the health effects associated with radon exposures; and (4) develop and evaluate methods to measure and reduce indoor radon concentrations.

The Department also coordinates its research on indoor radon with the other Federal agencies conducting research in this area. For example, DOE cochairs the interagency Committee on Indoor Air Quality (CIAQ) and its Radon Workgroup. The Department is represented on the Radon Subpanel of the Committee for Interagency Radiation Research and Policy Coordination (CIRRPC). In fact, DOE's coordination of its activities on radon extends beyond the United States. For example, DOE has participated in cooperative research planning discussions on radon within the Commission of European Communities (CEC).

In this context, DOE's research on radon focuses on several subjects, including source characterization, measurement methods, field studies, health effects, and control methods.

Concerning source characterization, DOE has conducted research to determine sources and entry mechanisms. Measurements of radon emanation rates from building materials and radon content in tap water samples, in combination with

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other findings, led to the conclusion that the soil under and around structures is usually the major source of radon in houses with high indoor radon levels. In addition, DOE research showed that radon enters buildings due to pressure differences between the soil and the building, indicating that care must be taken when adopting ventilation strategies that reduce the interior pressure of structures. These two conclusions, that is, that soil is usually the major source of indoor radon and that pressure-driven flow is the predominant building entry mechanism, are key results of DOE's research program.

Current DOE research devoted to radon source characterization includes analysis of data on radium concentrations obtained in an independent aerial survey of U.S. uranium resources, the National Uranium Resource Evaluation Study (NURES). This effort is attempting to determine relationships among radium concentrations in soil as determined from flyover data, soil permeability data, building envelope characteristics, and radon concentrations in houses. The initial objective of these efforts, proceeding in coordination with EPA's Office of Radiation Programs, is to develop a map which indicates where there is a strong probability of high radon concentrations in existing houses and where new houses should employ appropriate construction techniques to reduce future exposures. I would like to submit for the record a figure, labeled Figure 1, which shows preliminary results of this work for the Pacific Coast and Northwest region of the United States.

Concerning measurement methods, DOE has emphasized quality assurance, instrument development, and measurement protocol. For example, the radon calibration facility maintained at the DOE Environmental Measurements Laboratory (New York, NY) is one of four reference laboratories in an international intercalibration of radon instrumentation being sponsored by the Nuclear Energy Agency of the Organization of Economic Cooperation and Development. In addition, DOE research has developed portable passive radon monitors based upon radon progeny adsorption on charcoal. These monitors, which are deployed for 3-7 day exposure periods, have been used in field studies of radon, including measurements made in the Pennsylvania portion of the geologic formation known as the Reading Prong.

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DOE has also sponsored a number of monitoring activities in the form of field studies. In a landmark study nearly a decade ago, DOE researchers measured radon decay product concentrations in 21 houses in New York and New Jersey. This study was one of the first to examine "typical" houses, that is, houses that were not constructed on land filled with uranium mill tailings or on soil with unusually high radon soil content. The results showed that indoor radon levels were generally low, but several times higher than outdoors. Subsequent DOE field studies have shown that indoor radon levels are largely dominated by the strength and variability in the radon source, and not by the ventilation rate. These studies have concentrated on new and retrofitted energy efficient structures, including underground, passive solar, active solar, and air-tight residences.

The Bonneville Power Administration (BPA) recently conducted a major field study of 289 homes in the Pacific Northwest, including conventional homes and highly energy efficient homes equipped with air-to-air heat exchangers. The study found little differences in the radon concentrations between conventional homes and energy-efficient homes equipped with air-to-air heat exchangers. In addition, as part of its residential weatherization program, BPA offers homeowners an indoor radon measurement.

The collective results from earlier DOE field studies and additional studies conducted by others across the United States are summarized in a frequency distribution curve, Figure 2. This curve, based upon measurements in 552 houses located across the United States in areas where high concentrations of radon were not suspected, indicates that perhaps 2% of U.S. houses, over one million homes, have indoor radon concentrations higher than 8 picocuries per liter (pCi/l), which is the action level for remedial action recommended by the National Council on Radiation Protection and Measurements (NCRP). (Radon concentrations are measured in terms of pCi/l. One curie equals 37 billion radioactive decays per second, and one picocurie is one-trillionth of a curie.) However, the level of health risk at this level of exposure is unknown. DOE research will attempt to quantify the actual risk attributed to this level of exposure.

Concerning health effects, DOE research has addressed the physical mechanism by which lung cancer due to radon exposure is induced, and the degree of risk associated with exposure to low levels of radon. DOE researchers are

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attempting to identify and quantify in experimental animals the agents responsible for the production of lung diseases induced by radiation exposure. This research is developing exposure-response relationships in animals exposed to various combinations and levels of radon decay products and other mine-air contaminants. In addition, research is being conducted using microdosimetric computer models to understand the radiobiological effects of radon decay products on tissues.

DOE has also initiated a six-year epidemiologic study in eastern Pennsylvania to investigate the incidence of lung cancer at exposure levels of radon found indoors. This case control study will use 2,000 diagnosed female lung cancer cases obtained from the Pennsylvania Department of Health registry, and 2,000 control subjects. In addition to providing diagnostic and risk factor data, indoor radon measurements will trace the residential history of the cases. This research will seek to determine the risk, if any, of lung cancer from low-level indoor radon exposures.

Concerning control methods, DOE research has developed and evaluated several strategies which can reduce radon and radon progeny levels in buildings. These include air-to-air heat exchangers, filtration, and source control techniques. Field studies using air-to-air heat exchangers have demonstrated the ability to reduce indoor radon levels by increasing ventilation in an energy efficient manner. DOE studies on the effectiveness of electrostatic precipitation and extended surface filters have demonstrated the capability of these devices to reduce attached radon progeny concentrations, which may reduce the potential health risk from indoor radon. Research on other potential radon control strategies which may be more effective, including substructure ventilation, crack sealants, and more efficient heat recovery devices, are proceeding collaboratively with EPA, the Department of Housing and Urban Development (HUD), and others. It should be noted that ventilation and heat exchanger research is motivated by a range of indoor pollutants, of which radon is just one. The same mitigation strategies should apply to most indoor pollutants.

Finally, a major objective of DOE's indoor radon research program will be the synthesis of its research results into a form accessible for use by the public and private industry, and its subsequent dissemination. DOE intends to disseminate the results of its research activities to State and local governments.

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DOE ACTIVITIES IN THE READING PRONG GEOLOGIC FORMATION

I would now like to address DOE's work in helping to assess the magnitude and extent of elevated indoor radon concentrations in houses in the region of the Reading Prong. DOE activities in Pennsylvania have included aerial radiation surveillance, mobile gamma scanning, measurements of indoor radon concentrations, and the distribution of consumer information.

The results of the aerial radiation surveillance served to locate areas having gamma radiation readings above background levels. This provided Pennsylvania officials with reliable indicators and aerial photographs, which were used to conduct more detailed surveys with ground-based equipment. The results of the mobile gamma scan of the area identified numerous gamma radiation anomalies. These anomalies were generally detected along banks and road cuts, and occurred at elevations between 500 and 700 feet above sea level. Analysis of the gamma scan data and gamma spectrometry analysis of soil samples indicated naturally occurring radium and thorium to be the source of the elevated gamma radiation levels.

DOE researchers have also performed indoor radon concentration measurements in and around the region of the Reading Prong. These measurements were made in cooperation with local utilities and private homeowners. Indoor radon measurements made in 12 all-electric residential buildings in the vicinity of Allentown and Harrisburg in 1981 indicated that 6 of the 12 homes had indoor radon levels higher than 8 pCi/l. Measurements conducted in 31 residential buildings in the Philadelphia Metropolitan area in 1982 and 1983 indicated 14% of the homes had indoor levels above 8 pCi/l. Finally, recent measurements (1985) in Northeastern Pennsylvania measured 8 pCi/l or higher in 4 of 40 homes. The results from these measurements, although limited in number and not representative of a statistically random sample, agree with those obtained by the Pennsylvania Department of Environmental Resources.

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NEEDS FOR FURTHER RESEARCH

While much progress has been made toward a better understanding of indoor radon and its effects on health, additional work needs to be done in several areas. These concern the development of additional data on radon concentrations and anomalies, the assessment of the health risks associated with these findings, and the effects of energy conservation activities and various mitigation strategies on indoor radon levels.

Available data suggest that 2 percent of the U.S. homes experience 8 pCi/l, which corresponds to the NCRP action level, and might correspond to a real risk. Therefore, there needs to be research to develop quantitative techniques to find these homes in regions such as the Reading Prong. Control techniques to reduce indoor radon levels in both new and existing construction should be publicized by authorities in these regions. But before any of this work can be justified, accurate distribution, exposure, and risk assessments should be completed.

In response to market forces, many homeowners have taken steps to improve the air-tightness of their homes to reduce the energy required to heat and cool the outside air entering their homes. The effect of improving the air-tightness of U.S. houses is to cause a slight increase in indoor radon concentrations. Consistent with the National Energy Policy Plan, DOE will undertake research, as appropriate, to assess the level of actual risk attributable to these concentration levels.

The usual retrofit energy conservation measures to improve air-tightness -- caulking, weatherstripping, and the use of storm windows and storm doors in existing homes -- will generally increase the air-tightness of a home by no more than 20 percent. DOE research has demonstrated that these measures do not cause a large increase in indoor radon levels. New, tightly constructed housing may also experience elevated levels of indoor radon. The primary determinants of indoor radon concentrations, however, are geology, soil permeability, and the type of building construction -- for example, residences with basement, crawl space, or slab-on-grade designs. Energy conservation measures may have an effect, however small, on indoor radon concentrations. DOE believes there is a need to quantify the level of risk.

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Hence, the President's FY 1986 budget supports research to address the above needs with special emphasis on: (1) studying radon transport mechanisms into buildings, (2) modeling the behavior of radon progeny within buildings, (3) conducting animal and epidemiological lung dosimetry studies, (4) combining radon exposure data and the results of health effects studies to assess both population and individual risks from indoor radon, and (5) developing energy efficient control techniques to reduce indoor radon and radon progeny concentrations. DOE is also cooperating with the international bodies which are attempting to provide quality assurance for indoor radon measurements.

This concludes my prepared remarks. Thank you again for the opportunity to testify on DOE's research efforts devoted to the assessment and mitigation of indoor radon.

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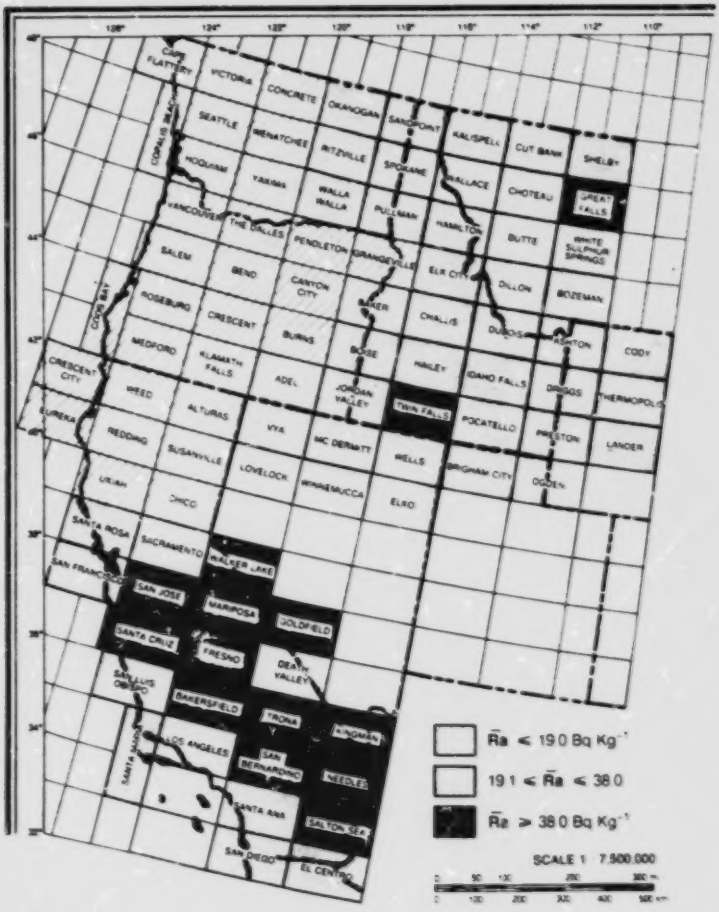

Figure 1

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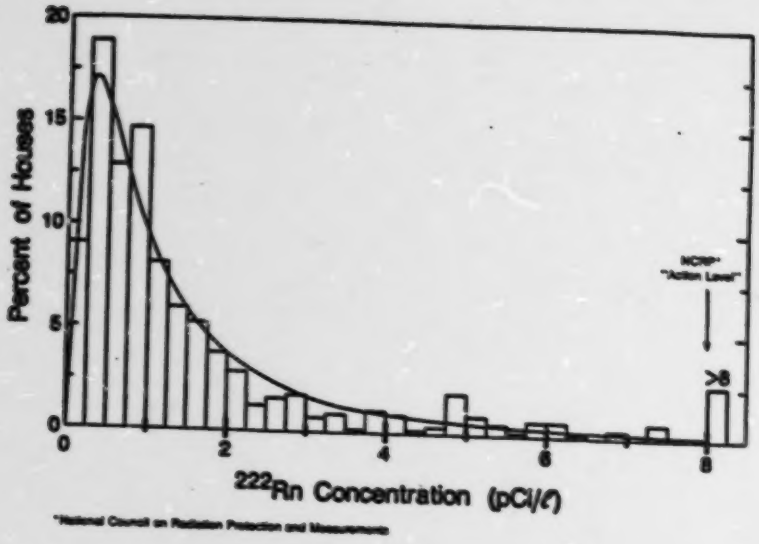

Frequency Distribution of ^{222}Rn Concentrations in 552 U.S. Homes

Figure 2

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Mr. SCHEUER. Thank you very much, Mr. Millhone.
Now, the Honorable Nicholas DeBenedictis.

STATEMENT OF HON. NICHOLAS DeBENEDICTIS, SECRETARY, PENNSYLVANIA DEPARTMENT OF ENVIRONMENTAL RESOURCES

Mr. DEBENEDICTIS. Thank you, Mr. Chairman and members of the committee.

My name is Nick DeBenedictis. I am the secretary for the environmental agency with the responsibility for this problem in Pennsylvania.

Two members of your committee, Congressman Ritter and Congressman Yatron, and I come from a State that has brought you problems such as Centralia, Three Mile Island, and now, unfortunately, radon. However, so you don't think we are coming with hat in hand, we like to solve our problems from within, but where we see there is national significance, we would like to share the experiences we have had and try to come up with a comprehensive program that will help all the citizens of this country, and I think we are at that point now.

I would like to take my time to reflect on some of the things that we have done since you heard the eerie story of Mr. Watras, and that is when we first got heavily involved in this program, in December of this year.

I would like to congratulate Mr. and Mrs. Watras and also the Pennsylvanians Against Radon group, represented today by Kay Jones and Kathy Varady for their active citizen input and the fact that they have allowed us to work with them. They have allowed their lives to be interrupted so that they can reveal this problem which we think has national significance, and I think they have to be congratulated for that.

One thing we have is, I think, we have the most experience of any State, including the Federal Government, in an actual hands-on program in monitoring, testing, and even the remedial design work needed for a radon program. Not to say it is all done and not to say we don't need a lot more, but at least to this point, I guess we have the best basic data to start our national program from.

I also think we have a model program for public information and community relations, which we thought was one of the most important parts of this study, not just the science but understanding we are dealing with a people problem.

I would like to just reflect on some of the things that we have done. We reallocated $9 million dollars out of our existing budget. We were already into our budget year, and I took money from existing programs to shift into this, and for our July fiscal year, the legislature did appropriate another $1 million, and today the Governor announced another $3 million program. So you see, we are spending money in our State for a problem that we think has statewide and national significance.

To give you some of the facts of what we have done, we have tested about 3,000 homes to date, so we think we have a pretty good statistical sample, although nowhere near the 20,000 homes we think may be affected in Pennsylvania. We have appreciated the help we have received from the DOE and the EPA in the initial

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testing and sampling that was undertaken earlier this year as we tried to define our problem.

One of the first things we discovered is what is the right level, and I think we are still groping for that, and you heard that from the testimony with the citizens. What we thought was best, though, was to try out some information documents, which the gentleman from Allentown referred to. It is pretty detailed. We didn't want to make it like a first-grade primer, so what we did was actually give some scientific data in layman's language, hopefully, so people could understand what radon is, get rid of some of the unknown, but it fell short of saying, "At this level this is what you should definitely do." We gave suggested action levels.

I think that is the one place where the Federal Government could help, because we don't want Pennsylvania setting a national standard. We have had to do the best with what we had to this point, so we think the .02 is a reasonable level to start with, but we would like to see a lot more epidemiological work, as the DOE representative has said, and also more scientific work on the remedial. But that is available, so we don't have to reinvent the wheel, hopefully.

The other thing, I think, that was important and that we have undertaken is, we actually hired a consultant to go in and look at 25 what we called generic homes—ranch homes, two-story colonials, brick, wood, stucco, whatever—to try to say, Here are some of the types of plans you can take on individually if you are in that home, and in phases, so you don't have to go for the most expensive fix right away. Maybe you can do it in phases, and if it goes down, fine.

Our dilemma, however, not many Pennsylvanians, even though we were offering this testing service, were taking the tests, less than 50 percent. Whether it is because of lack of understanding—maybe they just don't want government people knocking on their door saying we'll give you a free test or whatever—so what we have undertaken now is a fairly massive program of a mailout program which we will be announcing this weekend in the local papers of the major cities in our areas.

This is a mockup of the ad that will be in the paper. It basically gives you the opportunity to get a free kit. It is mailed to your home. Instructions are in English and in Spanish, exactly where to put it, leave it there for 3 months, mail it in, and we will then tell you privately what the results are.

If the results are higher than .1, we will send a team out immediately to your home and work with you. If they are at .02 or above, we would ask you then to put it into an area where there is more reasonable living level. See, the first level you put it in is in the most expected level of where you would find a high level of radon. It may be in a wine cellar, if you have a wine cellar, that you are never exposed to. However, if we find anything there, then we would want you to put it in your lowest living level. If you have a first floor den, then that is where we would want you to put it, so that we can get the exposure rate, your true exposure to the gas.

What we are asking for now, and the Governor announced today, is a low-interest loan program through our Pennsylvania Housing Finance Authority, and this is the one thing we heard from the

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citizens. To get full participation, some felt that they had to have some help. So in that sense, we have offered this help. It is a trial program. It is an initial program for the next 6 months to see the kind of demand we get.

We endorse Congressman Ritter's package of tax credits. We think that will help spur individuals to move to get these repairs that are needed. And we endorse the provision that was sponsored yesterday by Congressman Ritter, Congressman Yatron, and Congressman Edgar, showing bipartisan support of the research program to give EPA the $4 million to come up with these kinds of significant national studies that are needed for both the remedial action and for the health-based studies to set the levels.

We are satisfied that EPA is moving. We think that we are probably a little ahead of the curve on this basis, and we expect the national program to catch up, but it won't catch up without money and more resources dedicated to it.

Thank you.

[The prepared statement of Mr. DeBenedictis follows:]

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Remarks of
Secretary Nicholas DeBenedictis
Pennsylvania Department of Environmental Resources

October 10, 1985

Subcommittee on Natural Resources,
Agriculture Research and Environment
House Committee on Science and Technology

Mr. Chairman, members of the Subcommittee, thank you for inviting me to testify on Pennsylvania's experience in dealing with naturally occurring radon in homes. I am Nicholas DeBenedictis, Secretary of the Department of Environmental Resources. From our experience to date, we believe radon presents an environmental issue of national significance.

Since that dramatic day in December, 1984 when we tested a home in Berks County and found not high, but extraordinarily high levels of radon there -- 13.5 Working Levels -- Pennsylvania leads the nation in testing, monitoring, remedial design and community relations, helping citizens solve problems associated with radon gas trapped in homes and buildings. We've spent over a million dollars to date, with another million allocated for the coming budget year to fund the Department's activities in identifying the problem and protecting the health of our citizens. We've mounted an extensive radon survey program, in public buildings and private homes in Pennsylvania's section of the Reading Prong, testing air and water; we've designed remedial techniques for use in those buildings affected by the gas; and we've instituted a full community relations program to help

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citizens understand the health risks radon poses, while protecting their privacy by individually letting homeowners know their own levels of exposure.

Our efforts started as a testing program in several Pennsylvania townships and since then has broadened to the four counties in Pennsylvania known as the Reading Prong, affecting over 20,000 residents. Citizen involvement is crucial to this effort, and dozens of public meetings reaching hundreds of people have occurred in the past six months. I have personally visited the citizen groups and have met with leaders of Pennsylvanians Against Radon in the kitchen of the home of the president of that organization. Citizens have been directly in touch with the Governor's Office giving input to the proposal he is announcing today.

We've taken over 3,000 tests in homes; we've explained the effects of radon to those who are concerned about their family's increased risk of lung cancer; we've translated our complete informational packet into Spanish for Hispanic members who live within radon-prone areas; we've sought the help of the Environmental Protection Agency and the Centers for Disease Control to establish remedial action levels and health risk assessments; and we've enlisted the aid of the Department of Energy who have flown over the Prong area of Pennsylvania to provide us more information on where uranium deposits lay.

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And within our state, we've coordinated the efforts of the Pennsylvania Health Department to establish risk and action guidelines; with the Commonwealth's Department of Education to conduct a school sampling program; with the Department of Community Affairs to develop model building codes for radon-prone areas; and coordinated with the Pennsylvania Governor's Energy Council and our Council on the Hispanic Community on energy conservation matters and translations, respectively. We've shared our pioneering experiences and information with other states and with the EPA, too.

This morning Governor Dick Thornburgh announced two new programs the Commonwealth is instituting immediately, while waiting for the further federal assistance we have actively sought.

1) Pennsylvania is beginning the nation's first assistance program to help homeowners radon-proof their homes.

The Governor is proposing a $3.0 million loan program. Loans will be made available at 2 percent interest for low- and moderate- income families with annual incomes under $36,000. Loans at 8 to 9 percent (still 5 to 6 percent below commercial rates) for families with incomes over $36,000 annually. They will be targeted initially for the most serious problems. Loans will be made available to help residents eliminate radon gas in homes in Berks, Bucks, Lehigh, and Northampton Counties in the Reading Prong in Pennsylvania.

2) Pennsylvania is expanding our existing homeowner testing program by providing free monitors to assist citizens to protect their health in homes in areas of significant risk.

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We plan an aggressive campaign to reach all homeowners located in the Reading Prong in Pennsylvania with our new free monitoring program to be initiated next Sunday, October 13, with the placement of full page ads in newspapers in the area.

Residents within the Prong can fill out a coupon requesting a small measuring device, easily installed by homeowners, called a Terradex monitor. All eligible homeowners will receive a monitor in the mail with instructions to place the monitor in the lowest level of the home for three months. After three months, the homeowner is to mail the monitor back to Terradex, a contractor we have retained to process the monitor.

The Department will forward results to each homeowner. Those whose homes exceed 0.02 WL will be provided another monitor to place in a representative area in the home where people are exposed for a longer period of time. Those with .1 or higher Working Levels will be offered an immediate visit by our survey teams to carry out a more detailed survey and to recommend remedial actions so homeowners can make a better decision as to what type of remedial action is necessary.

Of the 3,499 tests done in homes and buildings since last January in the Berks County area, 40% or 1392 of them have readings above the Pennsylvania action guideline of .02 Working Levels. Ten percent or 352 tests showed levels above .1 WL which equates to smoking a pack of cigarettes a day or an increase lifetime risk of lung cancer of 5%. A Working Level is a unit of measure developed during studies of uranium miners to evaluate radon, and relates to radioactive energy in a liter of air.

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Our efforts have been limited to performing radon surveys in private residences by invitation only. We are of course testing public buildings such as schools, hospitals and prisons, to protect the public in these facilities.

As homeowners are responsible for their own remedial action, we felt it was the role of government to provide sound guidance as to the most cost effective, environmentally sound repairs needed for their homes. Very little information exists concerning remedial action for dwellings built in radon-prone areas.

Therefore, Pennsylvania contracted with a prominent consulting firm involved in radon activities-- the Arix Corporation of Grand Junction, Colorado. We asked them to carry out a study of the possible routes of radon entry into homes typically found in the area and to prepare generic plans for repairs in homes to provide permanent corrections. These generic plans show corrective action in phases, to minimize unnecessary repairs, and have been offered to residents before they begin their corrective action.

Since our preliminary work, EPA has conducted research on relatively inexpensive remedial action measures in 19 homes in the area. The results and permanency of these repairs are currently being evaluated, and the data is still preliminary at this time.

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In September 1985, Governor Dick Thornburgh wrote Lee Thomas, Administrator of the U.S. Environmental Protection Agency urging that EPA establish nationally based health standards, criteria, action guidelines and methodology for home repairs. In the letter he strongly sought federal funds for homeowner remediation and a continuance of EPA's pilot demonstration program using Pennsylvania as a prototype for a national program.

I am here today, as the Governor's representative, to tell you that in spite of Pennsylvania's massive efforts, we cannot do it alone - no state can.

With full knowledge that the public health risks radon poses are significant, and that radon is a national problem, Pennsylvania urges federal aid. It is now time for a strong federal presence to assist and guide states in resolving the very real problems radon presents to us as a nation.

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Mr. SCHEUER. Thank you very much, Mr. DeBenedictis.

Congressman Don Ritter of Pennsylvania.

Mr. RITTER. We don't have one more witness there?

Mr. SKINNER. No. I will be prepared to answer any questions you have about our mitigation efforts.

Mr. RITTER. Thank you, Mr. Chairman.

I would just like to give Mr. Meyers a chance to respond to the allegation that OMB has been holding up radon research. I have not found it in my experience. There are a lot of things we can blame OMB for, obviously, and I think we might certainly take issue with their approach not only during this administration but during other administrations on the whole problem of indoor air, the so-called Pandora's box of indoor air pollution.

But do you have a comment you could give us on that allegation?

Mr. MEYERS. Yes. In all fairness to OMB—now, this is based upon my 1 year in the Office of Radiation Programs—they have not held up any radon work to date.

Last year we did put together a proposal on radon for the fiscal year 1986 budget cycle. That never survived the Agency review process. It just never got into the system. OMB never saw it, so obviously they could not turn it down.

In the current budget cycle, as you know, we have prepared the Agency budget. It has gone over to OMB in total, and we just have not heard back from them. So I don't think it is fair to say that OMB has held back Federal funds to start a radon program.

Mr. SCHEUER. On that point, in March, Bernie Goldstein, Assistant Administrator, testified before us on the radon problem and gave us the following quote: "It is the administration's decision that we will not regulate indoor air, and since we will not regulate this, this is not to be a subject of research for EPA."

Then he continued: "But that research will continue in other parts of the Federal Government, through this interagency committee that is coordinating research." Now, that seems to me now, and it seemed to me then, to be rather bizarre.

Mr. MEYERS. There is a distinction there. Dr. Goldstein was talking about all of indoor air and the research aspects of it. We are in a program office that can do technical studies and analysis that is not part of the research effort, and the radon program that I mentioned that we have proposed to the Administrator has some facets of it that are research, but a large chunk of it is surveys, instrumentation development, mitigation measures, things that are not strictly research, that we would try to help the various States pass information on to the private sector.

Mr. SCHEUER. Then Dr. Goldstein continues, "I think basically what decision is being made is that EPA, since it becomes a pure research matter, therefore EPA will not play a role in this." I don't understand why, because it is a research——

Mr. SKINNER. Congressman Scheuer, maybe I could——

Mr. SCHEUER. Excuse me. And this is not coming out of your time, Don.

Mr. RITTER. I yield to the chairman.

Mr. SCHEUER. Thank you. [Laughter.]

I don't understand the logic by which they say it is a research matter, and because it is a pure research matter, the EPA will not

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play a role. Why shouldn't EPA play a role in developing the research and the knowledge by which Americans can take charge of their own problem, if they only know what the dimensions of it are, and how they can meet whatever the needs are of their own homes?

I mean, this is supply-side economics through and through, putting people in charge of their own health outputs and giving them the responsibility to do something about it once they have the knowledge, knowledge that is utterly impossible for them to derive by themselves and which is difficult and expensive and utterly uneconomic and silly for 50 States to try to develop separately. Why isn't developing the knowledge by which people can cope with this problem a proper role for EPA?

Mr. SKINNER. Maybe I can help you with that, Mr. Chairman.

I am from the Office of Research and Development. I have only been in the office very, very recently. We are doing research on radon, and we are doing research on indoor air. In fact, some of the research that we did showed some very promising results up in the Reading Prong area. We were able to achieve very significant reduction levels in several of the homes that we tested, well below the .02 level, a 98- to 99-percent reduction in the radon levels in those homes.

What we need to do is we need to test a large number of homes so that we can provide the guidance nationwide for the various types of houses, for the various types of construction techniques. We are moving ahead with the resources available to do that. I agree with the need that you expressed.

Mr. SCHEUER. Very good. I now yield back to my colleague from Pennsylvania, and I urge him to take his full 5 minutes starting now.

Mr. RITTER. All right. I am forever grateful to my beloved chairman.

It seems to me that the Federal Government does have—and I don't think there is any doubt that the Federal Government has a responsibility to provide the kind of overriding R&D capability that can be spread out amongst the 50 States—and we are talking about regions of the country which are involved with radon exposure which do not end at State boundaries. So there is no way you can separate this out.

Frankly, I wrote a letter to EPA in May as a result of consultations with EPA, and the response to that letter, as embodied in the program outlined in the New York Times article today, I think is on target. I think spending this money for research and analysis and understanding the mitigation techniques is right on target.

So I am very glad to see that. Now, I think what we are talking about here—we may be talking about two different things. At some point, if there is a mitigation responsibility for the Federal Government to work with the States—and I commend Mr. DeBenedictis and Governor Thornburgh for coming up with a mitigation responsibility to help the citizens of Pennsylvania—if there is a mitigation responsibility, we are going to vote it here in Congress, really. We are going to have to provide the kinds of resources which are not there at the present time to help the citizens, whether it is a

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tax incentive, whether it is a low-interest loan incentive. This is what these hearings are about.

So I think, Mr. Chairman, that you, in holding these hearings, have done a very important service, and I think we are getting our act together here in the Congress. I think EPA is getting its act together, and DER is probably ahead of the curve. It has done a reasonable job in responding. I would separate out the radon response from the indoor air response in that regard.

Now, one other thing. I would like to ask Mr. Millhone a question. The Department of Energy was very active in sealing off homes during the energy crisis. To what extent are we paying now in indoor air pollution and in radon exposure? To what extent are we paying for this sealing off of homes?

Mr. MILLHONE. I appreciate the chance to respond to that question, because I think there is a good deal of misinformation that is sometimes shown here.

The increased air-tightness of homes in order to save energy has had a very minor contribution to the increase in health risk as a result of radon. If you look at the factors that determine the level of radon in any given home, it depends upon the geology area; that is, the uranium and radium that are going through the decay process.

It also depends secondarily on the permeability of the soil that allows the soil gas to pass through to the structure. Those two are the primary factors determining radon level.

If you look at the average across the country, it is about 1½ picocuries per liter. If you do a very effective job of tightening your home, you may decrease the air changes by 20 percent. That would be a very effective job. So that would have the effect, in the average home, of increasing the radon level to 1.8 instead of 1.5 picocuries per liter. When we are looking at the Pennsylvania homes, we are looking at homes with 20 picocuries per liter, and in the Watras case, 2,700 picocuries per liter. So those are very order of magnitude larger——

Mr. RITTER. I appreciate that. That is a very interesting response.

One last question. What, in your opinion, is the proper mix of Federal and State and individual responsibility here?

Mr. SCHEUER. I am going to ask for unanimous consent for the gentleman's question to be answered in writing, and any other questions that they wish to submit in writing.

Mr. MILLHONE. Thank you.

[The information follows:]

INDOOR RADON RESPONSIBILITIES

The subject of indoor radon deserves the attention of Federal, State, and local governments and individual homeowners. The Department of Energy Role will be to continue to conduct research on indoor radon and to disseminate the results of this research to State and local governments for appropriate local action.

Mr. DEBENEDICTIS. I have one request. Since probably 10 times as many homes are affected in New Jersey and uncounted yet in New York, perhaps we could have a resolution to call it the Newark Prong or the Westchester Prong. [Laughter.]

Mr. SCHEUER. Congresswoman Roukema.

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Mrs. ROUKEMA. Mr. DeBenedictis, you gave me the perfect lead-in, since, as you know, I am not a member of this committee, but I am here representing a district in New Jersey that is heavily impacted or sits on the Reading Prong and is very concerned about this problem.

I am a little shocked, and I don't want to spend a lot of time on this, Mr. Millhone, but I am shocked by, if I understand your response on the subject of tightening the homes; therefore, airing out the homes, which has been the facile of mitigation, will have very little if any effect. Is that correct?

Mr. MILLHONE. Let me expand——

Mrs. ROUKEMA. I don't want to spend a lot of time on this question, because I have another one, and it may be one that I want to have answered in writing.

Mr. MILLHONE. When you increase the air-tightness of a home, you have a marginal improvement. You save energy, and you also cause the air changes in the house to be——

Mrs. ROUKEMA. But my question to you is, and if it takes a lot of time, I would like you to answer it in writing—my question is, my constituents have been led to believe that airing their homes is going to have a significant mitigating effect on their exposure to radon gases. I would like to have your professional response to that in writing, please.

[The information follows:]

INDOOR RADON RESPONSIBILITIES

The subject of indoor radon deserves the attention of Federal, State, and local governments and individual homeowners. The Department of Energy role will be to continue to conduct research on indoor radon and to disseminate the results of this research to State and local governments for appropriate local action.

Mrs. ROUKEMA. I have little time, and I do want to go on, as a Representative of the Fifth District of New Jersey, to the EPA people here.

I noted in the New York Times article that you were stated as working with the State of Pennsylvania. I trust you are working on this problem, also, with the State of New Jersey. Is that not correct?

Mr. MEYERS. We have contacted people in New Jersey, yes, as well as people in New York. We will be meeting and trying to set up some sort of coordinating function with all three States. The Administrator asked us to make certain that the Reading—I think it is called something different in New Jersey, by the way. In New York, it is called the Hudson Barrier.

Mrs. ROUKEMA. Well, I call it the Reading Prong, so we are talking the same language.

Mr. MEYERS. In any case, the Administrator asked us to work with all three States and see what help we could give to all three States, not just Pennsylvania.

Mrs. ROUKEMA. All right. Well, that leads me now to—and hope this report is somewhere near correct in terms of the intentions of the EPA, and I assume that this is the response to the legislation that has been introduced on a bipartisan basis. On the Senate side, it has been attached to the Superfund legislation for a national survey, and here in the House it is in other forms, but this is a

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response to that national survey and does go, indeed, beyond just the survey but to actual measures to reduce the radon levels. Is that not correct?

Mr. MEYERS. Well, the plan that we did put together would, in our research program, try to go beyond the Reading Prong and across the country to see what other kinds of mitigating measures do work, and they would be made available to the public.

Mrs. ROUKEMA. All right, but this is my real point. If I understand correctly in the testimony, you have had this under investigation and research for some 15 years. I would think that as you move now to this phase that we can expect some substantive assistance to the homes that are most heavily impacted in this particular area that we are speaking of. I mean, to our knowledge, this is the most heavily impacted.

My question is, would it not make sense, under some kind of expedited program, to make the Reading Prong area, including Pennsylvania, New Jersey, and New York, not only a targeted but more or less the laboratory area whereby your resources are targeted and the valuable data collected could be disseminated for application throughout the country?

Mr. MEYERS. That is exactly what the administration wants to do.

Let me mention one thing. The 15 years we have been working on radon-related issues mostly were related to mining wastes. In other words, we were gaining experience on identifying the problem and being able to measure it, but our relationship with the Reading Prong was just developed this past winter.

Mrs. ROUKEMA. I see. I am not being critical of you, but I am concerned that we get things moving here because people's health is in serious jeopardy, potentially. And if that health hazard has been exaggerated, then we ought to know it as soon as possible. I want my people and Mr. Yatron's and Mr. Ritter's people to have the benefit of your expertise and to move in.

Now, I have conversely had a problem in another related kind of toxic waste cleanup problem that involved DOE, and I know that we can get into a terrible bureaucratic morass here, and I certainly hope that EPA intends, through this process, to expedite matters and not to make them more complicated and not to create a heavy bureaucratic overlay that is going to slow progress rather than expedite it.

Mr. MEYERS. That does not seem to be the case. I mentioned that there are groups now set up to make certain that we don't step on each other's feet.

Mrs. ROUKEMA. Will you come to my district in New Jersey?

Mr. MEYERS. I would be delighted.

Mrs. ROUKEMA. Thank you.

Mr. SCHEUER. Mr. Meyers, are you aware of OMB's treatment of the Research Office request on indoor air research for fiscal year 1986?

Mr. MEYERS. No; I am not, sir. I just don't know how OMB treated the research program.

Mr. SCHEUER. You don't know how the research program is being treated?

Mr. MEYERS. John?

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Mr. SKINNER. I wasn't with the research program at that time, but my understanding is that there was a budget request that was made for indoor air research, and that was not included in the President's budget.

Mr. SCHEUER. In other words, it was turned down?

Mr. SKINNER. It was turned down either by—I don't know who or why, but it was not included.

Mr. SCHEUER. Mr. Meyers, I don't want to go over my 5 minutes, so I am going to ask you two questions, if you will be kind enough to answer them by mail. We will hold the record open if there is no objection—there being no objection, it is so ordered—for about 10 or 12 days.

First question: Has the Radiation Office requested funds for indoor radon research? Second, what is the status of the proposed 5-year radon program?

I would ask unanimous consent for all members to ask any further questions by mail, and we will hold the record open for 10 or 12 days. We welcome that.

[The information follows:]

Question. Has the Radiation Office requested funds for indoor radon research?

Answer. No funds have been requested in EPA's FY 86 budget. However, EPA has accelerated its assistance to affected States. Because the FY 87 budget process is still in its early deliberative stage, the Administration has not made any final decision on an appropriate funding level for EPA's radon effort.

Question. What is the status of the proposed 5-year radon program?

Answer. EPA's proposed radon program is currently being reviewed by other participating Federal agencies involved in the radon effort, particularly DOE, which currently funds its own radon efforts.

I want to particularly thank my colleagues for the really admirable bipartisan interest and involvement and support they have given to this program from the inception.

I want to thank this panel for their excellent testimony. It is now after 5 o'clock. You have been patient, you have been understanding, and I thank you very much.

We will now go to the last panel: Dr. John H. Harley, National Council on Radiation Protection and Measurements; Dr. Anthony Nero, Lawrence Berkeley Laboratories; Dr. Bernard Cohen, department of physics, University of Pittsburgh; Dr. Richard Wilson, department of physics at Harvard University.

Gentlemen, I want to apologize for keeping you here until after 5 o'clock. I hope you have found at least some of the testimony illuminating, as we have. We are going to operate on a strict 5-minute timetable, so we would ask you to summarize your remarks, and when the bell goes off, try to just finish that sentence or one additional brief sentence so we can get on to the next witness.

Dr. Cohen will be the first witness. Let me say to all of you that your prepared remarks will be printed in full at the point in the testimony where you have testified.

Please proceed, Dr. Cohen.

STATEMENT OF DR. BERNARD L. COHEN, PROFESSOR OF PHYSICS, UNIVERSITY OF PITTSBURGH

Dr. COHEN. Rather than summarize, I thought I would try to hit a few high points in my testimony.

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First is this question: Is radon a Reading Prong problem, mainly? In the first place, all the estimates that have been given about this 10,000 or 20,000 deaths a year, that applies to normal radon, the amount of radon that is present on an average in all U.S. homes all across the country.

The second point is that we did a survey of five counties in Pennsylvania, three traversed by the Reading Prong and the other two in central Pennsylvania, and each of the two counties in central Pennsylvania had higher average radon levels than the three Reading Prong counties.

The third point is, we did a national survey of homes of 450 physics professors from 101 universities in 42 States plus the District of Columbia, and the areas of the universities in which the levels were highest, the top 10 were North Dakota, Colorado, Nebraska, Indiana, Kentucky, Minnesota, Connecticut, South Dakota, and Tennessee.

The university in the Reading Prong area, Lehigh University, ranked No. 18, and the other two universities that were close by, Wilkes College in Wilkes-Barre, PA, ranked 26th, and Temple University in Philadelphia was No. 76.

So, according to that, it seems clear that radon is a national problem. We now have very little understanding of where radon levels are high, but there are probably many places across the country where they are.

Another point I wanted to make, which is in my testimony is this: I feel as though this is an area where we should have more involvement of university scientists. Problems on radon vary with locality, and they are most efficiently handled by local experts. Very often they require on-the-scene efforts or on-the-scene knowledge of the details of what type of houses are in what parts of the town, and so forth.

University scientists are on the scene in every locale. They don't need a lot of high technology or expensive equipment to do work in radon. Most of the hard work is well suited to being handled by part-time student help, which is readily available at low cost. So I really feel as though the university scientists and their students—and I include colleges—are available in every locale across the country, and they ought to be used in this effort to do something about the radon problem.

Another point I would like to make is to put the radon problem in perspective. Our country is spending about $10 billion a year to reduce the hazard of nuclear reactor accidents. But even according to the antinuclear activist organization, Union of Concerned Scientists, radon is 100 times more of a problem than reactor accidents as far as radiation is concerned.

When a cell of the human body gets hit by a particle of radiation, there is no way that that cell can know whether it came from radon or from something made in a nuclear reactor. Harrisburg, PA, residents get more radiation exposure from radon every day than the total radiation they received from the Three Mile Island accident.

The scientific community unanimously agrees, I believe, to the best of my knowledge, that the health impacts of radon are much greater than the combined effects of medical x rays, reactor acci-

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dents, radioactive wastes, bomb testing in the atmosphere, and everything else that people worry about on radiation. Radon is far and away more important than all of these things combined, but yet the Government spending on radon is less than 1 percent of what it is on each of the above-mentioned problems.

I would like to also point out that research on radon has been increasing in every other country in the world over the past 5 years, but it has been decreasing in the United States.

For example, the Canadian program has been something like ten times the United States program, although Canada has only one-tenth the population and one-tenth of the resources of the United States. It turns out, in fact, that radon is much less of a problem in Canada than it is in the United States.

So in summary, then, I feel as though this is a very important problem. It needs a lot of attention. I certainly appreciate the opportunity to tell you about these things.

[The prepared statement of Dr. Cohen follows:]

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Testimony of Bernard L. Cohen (Prof. of Physics, Univ. of Pittsburgh)
for
House Committee on Science and Technology
on
Radon Contamination: Risk Assessment and Mitigation Research
October 10, 1985

1. The risk from radon in homes

A typical estimate is that radon in U.S. homes is killing about 10,000 American citizens each year. If the same methods were used to derive this estimate as are used to derive estimates for radiation from the nuclear industry, the number of deaths would be several times higher, at least 30,000 per year.

Regardless of the risk estimation procedure, there is unanimous agreement in the scientific community that the cancer risk from radon far exceeds that from all of the other widely publicized radiation threats in our Society combined. Let me cite a few examples:

- We are spending at least a billion dollars per year to keep medical X-ray exposures as low as practical, but our average radiation exposure from radon is about 10 times higher.
- We are spending hundreds of millions of dollars every year to reduce routine releases of radioactivity from nuclear plants, but radon is giving us thousands of times more radiation exposure than we get from that source (a hundred times more for people who live closest to nuclear plants).
- We are spending hundreds of millions of dollars every year to improve the security of radioactive waste burial and thereby reduce radiation exposure to future generations, but even with one-tenth of that effort, their radiation exposure from our waste would only be one-thousandth (0.1%) of what we now get from radon.
- We are spending billions of dollars every year to reduce the threat of radiation from reactor accidents, but even if we use the estimates by the anti-nuclear activist organization Union of Concerned Scientists (which are widely believed to be inflated a hundred-fold), our potential average radiation exposure from reactor accidents without these added expenditures would be only one percent (1%) of what we are now getting from radon. Citizens of Harrisburg, PA get more radiation exposure from radon every day than they got in total from the Three Mile Island accident.
- We are spending perhaps $100 million per year to test nuclear bombs underground rather than in the atmosphere, but radon is giving us a hundred (100) times as much radiation exposure as atmospheric bomb testing would give.

In summary, no scientist disputes the fact that our radiation risk from radon in homes far exceeds that from all other radiation threats in our Society combined, except, of course, for nuclear war.

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2. Extent of radon contamination in the United States

It is often implied that the Reading prong area of Eastern Pennsylvania, New Jersey, and New York is the principal area of danger from radon, but there is little scientific basis for that position. I have recently completed a survey of radon levels in randomly selected houses in five Pennsylvania counties, three traversed by the Reading Prong (Berks, Lehigh, Northampton) and two in Central Pennsylvania (Cumberland, Lebanon); the latter two had substantially higher radon levels than those in the Reading Prong.

I have also recently completed a small national study of radon levels involving measurements in 450 houses of physics professors from 101 universities in 42 states plus District of Columbia. With only 4 or 5 houses from each university, the average level in each location can only be estimated very crudely, but those with the highest radon levels, in descending order, were:

1. U. of North Dakota	11. Kearny State U. (NB)
2. U. of Colorado	12. U. of Tennessee
3. N. Dakota State U.	13. U. of Kansas
4. U. of Nebraska	14. U. of Idaho
5. Indiana State U.	15. Iowa State U.
6. U. of Kentucky	16. Georgia Tech
7. Carleton College (MN)	17. Geo. Washington U.
8. U. of Connecticut	18. Lehigh U.
9. S. Dakota State U.	26. Wilkes Col.
10. Memphis State U.	76. Temple U.

Note that Lehigh University (#18) is in the Reading Prong, and Wilkes College (Wilkes-Barre, PA) and Temple Univ. are also in Eastern Pennsylvania.

From this list it must be clear that radon is a national problem, not a Pennsylvania-New Jersey problem. In which areas of the nation are radon levels high? No one knows, because only a very tiny fraction of the United States has been explored. The Reading Prong problem was discovered by sheer luck — the resident of the world's highest known radon level house happened to be employed in a nuclear power plant.

While high radon levels attract most of the attention, even normal radon levels pose a substantial health impact. The risks cited at the beginning of my testimony are based on normal radon levels, found everywhere throughout the country. Moreover, these levels are being increased by government sponsored programs on tightening of houses to save energy; in fact, this artificial increase in radon levels, believed to be causing many thousands of deaths each year, is partially financed by the U.S. Government through tax credits. Incidently, this aspect of the radon problem makes energy conservation by far the most dangerous energy strategy from the standpoint of radiation! It gives us many times as much added radiation as even the anti-nuclear activists claim we will eventually get from nuclear power (including reactor accidents).

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3. Measures to reduce radon risks

By far the most important measure to reduce radon risks is to identify houses where radon levels are high so that remedial action can be taken. This will be a long process, requiring testing in many millions of houses. On the other hand, it would not be excessively expensive since a reliable test can be done for less than $10.

In the great majority of cases, expensive drastic action to reduce radon levels would not be called for. In my research, I have found two simple and easy ways to obtain substantial reductions. One is to open two windows in the basement and install a large fan in one of them. In my tests, this reduced the radon level to about 3% of its original value, a spectacular improvement. In cold climates this can be done without adverse effects for 6 months each year, cutting the radon exposure in half. The simplest remedial action I have found for Winter is to operate air cleaners such as electrostatic precipitators or ion generators. They cost only a few hundred dollars, and cut the radon risk in half, while providing the other benefits of clean air. With these two measures, the radon risk is reduced to one-fourth of its original level. In the great majority of cases, that would provide sufficient relief.

Beyond this, my experiments have been singularly unsuccessful, in spite of rather extensive efforts. However, others have had substantial successes, especially with pumping air out from under basement floors and from certain types of drainage systems.

My efforts are continuing, and I am optimistic about new approaches I will soon be trying. However, solutions are different for different house types and different construction practices. Many different solutions will have to be developed, and they will vary considerably from one locality to another.

4. Research needs

The most important areas where research is needed are:

(a) Determination of the risk of lung cancer from radon exposure.

As in the case of all other low level radiation such as releases from nuclear plants, reactor accidents, nuclear waste, and fallout from bomb tests, health effects of radon in houses are estimated from studies with high level exposures such as those to miners, A-bomb survivors, and radiation therapy patients. Until now, there has been no direct evidence for excess cancer from low level radiation. However, if the accepted methodology is correct, the effects of environmental radon should be relatively easy to observe directly. If they are not found, this would greatly reduce risk estimates not only for radon but for all other radiation such as that from the nuclear industry.

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(b) Location of houses with high radon levels

This is most efficiently done by finding areas with high average levels and narrowing down from there. Development of methods for predicting high radon levels from geological evidence or construction characteristics could be useful here, but direct measurements of radon may be the cheapest and most effective approach. No geologist has yet successfully predicted in advance where high radon levels will be found.

(c) Development of low cost, effective remedial action procedures

This is a matter of trying many approaches and gaining experience on where they do and do not work. Different types of construction in different geographic areas make this a long process. There is lots of room for new ideas.

(d) Development of low cost methods for measuring radon levels, and tracing its mode of entry into a house

Most measurements of radon in homes now cost more than $25 per measurement, but I have developed a $10 measurement and I believe the cost can be brought down to $8, or possibly even $6. per measurement. Tracing the mode of entry of radon into a house now can only be done by experts and costs many hundreds of dollars, but I believe methods can be developed to put it on a "do-it-yourself" basis at a cost of perhaps $50.

5. The U.S. research program on radon in homes

At the beginning of this testimony, I noted how much we are spending to reduce our radiation exposure from radioactivity releases, from reactor accidents, from radioactive waste, and from bomb test fallout. In each of these, we are spending over 100 times as much money as we are spending on radon in homes, in spite of the fact that radon in homes is over 100 times more important as a health hazard than any of them. I can well understand that political considerations often over-ride the humanitarian goal of maximizing life-saving, but I find it impossible to justify this factor of 10,000 (100 x 100) discrepancy in cost effectiveness for protecting the public from radiation. Nowhere else in the World is this folly being repeated. Canada has done 10 times as much on radon in homes as the U.S. in spite of the fact that we have 10 times more population and resources. In every other country, research on radon in homes has been accelerating rapidly in recent years, whereas in the U.S. it has been in rapid decline.

The worst aspect of the U.S. program is lack of involvement of university researchers. Radon in homes is best suited to study on a local basis. It is far more efficient for local researchers than for remote DOE or EPA laboratories to get into homes to make measurements, to determine sources of radon, and to work out remedial actions. University researchers are ideally suited to such tasks, and they are available on the scene in every area of the nation. But they have not been able to obtain support.

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There is one university scientist who worked for many years on a basic research program in an area with essentially no conceivable potential impact on Society, supported at a rate of $200,000 per year and winning international recognition and prestigious prizes. When he abandoned his basic research and turned to studies of radon in homes, he eventually achieved $40,000 per year support, which is close to the highest, if not the highest, support level for any university program, but his support level has now dwindled to $20,000 per year. I know other excellent and well recognized scientists who have never been able to obtain any Federal support for research on radon in homes.

The research programs at EPA and DOE Laboratories has also had very "tough sledding." Many of the top scientists in indoor radon reseach five years ago have been forced to leave the field because of lack of support.

In summary, I believe the U.S. research program on radon in homes needs substantially increased support with special emphasis on involvement of large numbers of university researchers from every area of the country.

6. Submission for the Record:

I submit a paper on "Radon: Our Worst Radiation Hazard" which has been submitted for publication in "Atlantic Monthly."

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RADON: OUR WORST RADIATION HAZARD

Bernard L. Cohen

University of Pittsburgh

What is the principal radiation hazard to the American public? Nuclear power? Medical X-rays? Cosmic rays? Not any of these by a long shot. Many times more of a hazard than all of these combined, is radon, a radioactive gas that contaminates the air in our homes.

Uranium is a naturally radioactive element that occurs in small quantities in all rock and soil. Being radioactive, uranium atoms undergo a series of transformations, eventually becoming radon. Since radon is a gas, it tends to percolate up out of the soil into the air where it, and its radioactive decay products, can easily be inhaled by people. This exposes our bronchial surfaces to radiation which can cause cancer. By this process, radon is now killing many thousands of Americans every year.

The earliest record of this problem was in a 16th century medical book in Latin which reported that most men who worked in mines in the Erz Mountains which separate Bavaria (Germany) from Bohemia (Czechoslovakia) died from a "Mountain disease." These mines, near the Bohemian town of Joachimsthal, were very famous for the silver they produced, and the coins came to be called "thalers." That is the origin of one word we all know, "dollars."

The mines continued to operate, and the miners continued to die, through the centuries. As medical science progressed, in 1879 it was rec-

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ognized that the "mountain disease" was actually lung cancer. Although one or two cases of lung cancer had been reported earlier, this was the first real recognition of that disease which is now killing 130,000 Americans every year.

Radioactivity and radon were discovered around the turn of this century, and it was soon learned that radiation can cause cancer. As the clues accumulated, by the 1940s, the suspicion became widespread that radon was the cause of the lung cancer in the Erz Mountain miners. There was a great deal of uranium in the rock — in fact uranium was, at that time, the principal material being mined — and the radon generated from it was percolating into the mine air where it was inhaled by the miners. The ventilation in the mines was greatly improved, reducing the measured radon levels, and the lung cancer incidence among the miners eventually declined.

The scientific studies continued. Since the Erz Mountain mines were notorious for their wide variety of dangerous chemicals and cold, wet working conditions, it was decided in the 1950s to study the U.S. uranium mines where, aside from the radon, conditions were much healthier. By the mid 1960s, these studies made it clear that there were also excess lung cancers among the U.S. uranium miners. Those with a radon exposure comparable to that of the Erz Mountain miners had equal cancer rates. For those with less radon exposure, the cancer rates were proportionately lower. As a result of these findings, strong action was taken to improve ventilation and by 1970, the radon levels in U.S. mines had been drastically reduced. It is too early to tell the results of that action as the miners continue to die from lung cancer at about a constant rate, presumably from their radon exposure prior to 1970.

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Investigations continued. Coal mines were found to have low radon levels — for geochemical reasons, coal and uranium do not usually occur together. Coal miners were found to have large excesses of all sorts of lung diseases, but not of lung cancer. This confirmed the theory. Various other mines were studied — fluorspar mines in Newfoundland, zinc and lead mines in Sweden, various metal mines in the U.S. — and where radon levels were high, the miners were found to have excess lung cancers, roughly in proportion to their radon exposures.

In 1976, a new study came from the Czechoslovakian mines. While the radon levels were much lower than in earlier years, there was still an excess of lung cancer among miners who began working after 1948, and this excess was less than that experienced earlier by roughly the factor by which the radon level had been reduced. In fact, all the data from all the miner groups studied are consistent in giving roughly the same cancer risk per unit of exposure to radon.

By the early 1970s, a great deal of information had accumulated on the excess cancer incidence from other types of radiation episodes, like the atomic bombs dropped on Japan and medical therapy treatments with heavy doses of X-rays. It was not trivial to compare these results with the effects of radon because the latter depend on the probability for inhaled radioactive particles to stick to bronchial surfaces and the thickness of mucus layers which partially shield the sensitive body

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cells from the radiation. But these were studied, allowing the radiation dose from radon to be expressed in the same terms as A-bomb and X-ray exposure. Sure enough, the lung cancer risks from a given dose was roughly the same for radon as for the others.

This cemented the case. There could be little doubt that radon was largely responsible for the excess lung cancer among the miners. With all these data, radon induced lung cancer has become one of the best quantified health effects of radiation. By measuring a person's exposure to radon, his risk of developing lung cancer can be estimated.

Armed with this information, scientists set out to find other situations in which exposure to radon is important. They measured the radon levels in air all over the world, even over the oceans and in Antarctica. They measured the effects of temperature, of barometric pressure, of rain and of snow on radon emission from the ground. They studied the occurrence of radon in natural gas, in water from wells, in geysers, in oil, in concrete. About the only place it wasn't often measured was in the air of people's homes. There were lots of interesting findings: Carlsbad caverns, a prime tourist attraction, has uncomfortably high radon levels for the guides and souvenir vendors; growing corn "pumps" radon out of the ground into the air. But when all was said and done, the radon to which people are ordinarily exposed outdoors represents a relatively unimportant radiation exposure, comparable to cosmic rays or to the radioactive materials in our bodies (mainly potassium) that are vital to life.

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There was a big "splash" in the mid-1970s when two Environmental Protection Agency (EPA) scientists calculated the effects of radon emitted from uranium ore processing mill wastes, called "mill tailings." Adding up the effects over hundreds of thousands of years, the waste generated in fueling one large nuclear power plant for one year (one plant-year) would eventually kill about 200 people with its radon emissions. Since coal burning power plants are typically estimated to kill about 25 people per plant-year with their air pollution, the antinuclear people had a field day with their first scientific evidence that nuclear power was more harmful to health than coal burning. Their glee was short-lived. It was soon found that radon emissions from mill tailings can be drastically reduced rather cheaply with covering materials. Regulations now require that these covers reduce the radon emissions 20-fold, cutting the fatality toll to 10 per plant-year. This is still hundreds of times more than the toll expected from all the other radioactive waste generated by nuclear power that receives so much media publicity. If someone worries aobut radioactive waste from the nuclear industry, he should devote 99+% of his worrying energy to the radon emitted from uranium mill tailings.

The final blow to the claims that radon made nuclear power as harmful as coal burning came when it was pointed out that mining uranium out of the ground to fuel nuclear power plants saves lives by averting future radon emissions. In fact several hundred lives per plant-year will eventually be saved in this way, making nuclear power overwhelmingly a life-saving technology.

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It was later pointed out that, since coal ash contains several times as much uranium as normal soil, it serves as a source of increased radon emissions. Calculations show that this radioactive waste from coal burning is many times more harmful to human health than all of the radioactive wastes from nuclear power. If one is worried about radioactive waste, he should worry much more about coal burning than about nuclear power! All because of radon.

Throughout this period, there were sporadic reports on measurements of radon levels in houses, and they were coming out higher than expected. This was variously blamed on building materials, on water supplies, on natural gas, or on nearby nuclear facilities, and all of these problems were investigated. But it turned out that, with rare exceptions, none of these were the cause.

The source of the radon in homes was simply the ground beneath them. Radon is percolating up out of the ground everywhere, typically 6 atoms per second from each square inch of soil. If it emerges outdoors, it spreads up to high altitudes and becomes highly diluted. But if it emerges under a house and finds its way inside, it is trapped for some time. In an average house, the radon level is about ten times what it is outdoors, which makes it by far the largest radiation source to which we are exposed. Official estimates

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of the number of lung cancer deaths it causes annually in the United States range from 3500 to 25,000; for discussion purposes, we will use an intermediate estimate of 10,000.

All of this was coming to light at a time when the U.S. Government was urging people to seal their houses more tightly to save energy used for Winter heating and Summer air conditioning. In fact, our Government is heavily subsidizing such activities through tax credits. The general recommendation is that air leakage in houses be cut in half. If everyone followed that recommendation, the average radon exposure would be doubled, killing an additional 10,000 Americans each year. Even the anti-nuclear activists claim that nuclear power will kill, on average, only a few hundred Americans per year (typical estimates are more like 10 per year). That makes "Energy Conservation" by far the most dangerous energy strategy from the standpoint of radiation exposure.

This also has legal ramifications. According to any of the estimates, a substantial fraction of all lung cancer in non-smokers is due to radon in homes. If a non-smoker follows government recommendations and takes tax credits to tighten his house, and if he later gets lung cancer (as 7,000 non-smokers do each year), there is a substantial probability — perhaps 40% — that the Government caused his demise. There have been several cases involving industrial or defense-related radiation exposures in which courts have awarded large damage claims even though the probability was less than 10% that the cancer was due to the radiation for which the defend-

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ent was responsible. The U.S. government is thus vulnerable to thousands of million dollar liability suits each year.

In the last few years, programs on measurement of radon levels in homes were started in several countries. Sweden and Finland turned out to have an average level 2.8 times and 2.5 times higher respectively than what is believed to be the world average. Germany was about average. England and Canada were below average. In the United States, the Environmental Protection Agency started up programs in their facilities. Las Vegas, Montgomery (AL) and Washington (DC). There was rapid progress for a while but then word came down from above — environmental radon is not the business of EPA. The best people in radon research were transferred to other fields.

The Department of Energy's Office of Health and Environmental Research has kept a small radon program going, but it is barely hanging on. There is great interest in radon within the scientific community, but with no money to support research, no one can enter the field. We don't know the average radon levels in the United States.

The risk from radon in our homes can best be understood in terms of the loss of life expectancy it causes. For the World average level, this is about 35 days. By comparison, our loss of life expectancy from some other risks are: fire and burns - 27 days, falls - 40 days, drowning - 40 days, motor vehicle accidents - 200 days, being 25 lb overweight - 750 days,

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being poor (vs well-to-do) - 1500 days, smoking a pack of cigarettes daily - 2400 days. Compared to these risks, our 35 day loss of life expectancy from radon doesn't seem too terrible. But let's compare it to other radiation risks: employment as a radiation worker in a nuclear plant from age 18 to 65 - 12 days, medical X-rays (average person) - 2 days, nuclear power - 0.04 days according to most scientists, or 1.5 days according to the anti-nuclear activists. If anyone is worried about hazards from radiation, clearly he should begin with the radon in his home.

The 35 day loss of life expectancy is for a house with an average radon level. It is estimated that 35,000 homes in Sweden have over 20 times this average level, increasing the risk 20-fold. The Swedish government is planning a program to fix these houses at a cost of about $1,000 each. This program will save a life for every $10,000 spent. By comparison, highway safety improvements typically save a life for every $150,000 spent, and reducing pollution from coal burning costs about $1 million per life saved. Spending to protect people from nuclear industry radiation is much higher still on a per life saved basis. If one is interested in a cost-effective way to save American lives, finding and fixing homes with high radon levels provides a wonderful opportunity.

Nuclear power plants have alarms which go off if a departing worker is contaminated with radioactivity. For one worker in a new plant near Pottstown, PA, however, the alarms went off when he entered the plant! There was lots of disbelief, followed by head-scratching. The problem was finally

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traced to radon in his home where measurements revealed a level 2500 times average! While that retains the distinction of being the highest level ever measured in a house, a dozen of his neighbors' houses had levels more than 200 times average. Needless to say, the people living in them are worried and scared. There is no disaster relief for them as there is for victims of floods, tornadoes, and earthquakes. They can't afford to move out. EPA has a small research program developing techniques for fixing the problem. In the meantime, all the householders can do is stay in their homes and live with the radiation.

High radon levels in houses are not a new problem in Pennsylvania. In the only county where the average level has been determined, it is 9 times the world average; in that area, the risk of dying from radon exposure is higher than the risk of being killed in a motor vehicle accident. There is good evidence that many areas of Pennsylvania have comparable radon levels. Citizens of Harrisburg get more radiation exposure every day from the radon in their homes than they received in total from the Three Mile Island accident. There is also evidence that the high radon areas in Pennsylvania extend northward into New York state and southward into Maryland, which is as far as they have been traced.

There are indications of high radon levels in a few other places, but basically very little is known about where else it may be a problem because very few areas of the country have been investigated.

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Radiation causes cancer by a single particle of radiation striking a single molecule in the nucleus of one of the trillions of cells of which our bodies are composed. When that molecule is struck by a particle of radiation, there is no possible way for it to "know" whether the particle of radiation came from something produced in a nuclear reactor, or from a radon atom. The processes that follow must be exactly the same, and the risks must therefore be exactly the same. But the difference between how our Society treats these identical risks is astounding.

The U.S. Government has myriads of regulations and programs to protect the public from the nuclear industry's radiation, and these are easily translatable into a cost per life saved. Equipment to reduce radioiodine releases from nuclear power plants is required if it saves a life for every $100 million spent. Some of our radioactive waste management programs are spending over $500 million dollars per life saved. In 1975, the Nuclear Regulatory Commission estimated that accidents in nuclear power plants would kill an average of one person per plant over its operating lifetime, and since that time it has been constantly introducing new requirements to improve safety. This has quadrupled the cost of a plant, raising the price tag by $2 billion. That's $2 billion to save one life.

Judging by the Swedish experience, we can save a life from radiation for every $10,000 spent on radon reduction. Saving lives by reducing radon exposures is thus 10,000-200,000 times more cost-effective than what we are doing to save lives from the nuclear industry's radiation. But hardly anything is being done about radon in this country.

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Our government responds principally to public concern and there has been little public concern about radon. That explains the absence of money for radon research. But why is the public so unconcerned about radiation from radon while it has gone berserk with fear over the much lower radiation risks from the nuclear industry? The answer is that the public doesn't even know about radon, because the media haven't covered it much. Until they do, there will be little public concern, and consequently, little Government action.

That, sad to say, is where the radon story now stands — thousands of Americans dying from its radiation every year, and practically nothing being done about it.

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Mr. SCHEUER. Thank you very much, Dr. Cohen. You make some very dramatic points.

Dr. Richard Wilson.

STATEMENT OF DR. RICHARD WILSON, MALLINCKRODT PROFESSOR OF PHYSICS, HARVARD UNIVERSITY

Dr. WILSON. I would also like to summarize very briefly.

I would like to make another stronger point as to how big the problem is compared with others. I believe the number of lung cancers calculated, which is on a reasonable basis, exceeds the number of cancers reduced by all EPA actions to date, and so, if you are trying to make cost effectiveness of EPA budgets, I think you have to bear that in mind.

It is also interesting to bear in mind that a number of people have been talking in some way or another about radon gas for some time. Professor Dade Moeller, from Harvard School of Public Health, cannot be here today but he has been working on radon for 20 years and has been measuring it in Massachusetts for 15. He has been short of budget, and I remember we had a budget 10 years ago of $20,000 from EPA, and a student wrote a report giving a radon gas model, a very good model which was completely right, and that $20,000 was not renewed by EPA because the subject was not interesting.

The question is, Why has this been ignored? I think it is partially because it is a problem with no one to blame and no one to sue, and therefore no one can make any money out of it, and you cannot have lawyers getting rich by bringing it to people's attention.

That does not mean to say that we should not pay attention to it. As was mentioned earlier, it is like floods, hurricanes, and other things, and our society has reduced a lot of loss of lives by paying attention to hurricanes and so on. Just the warnings we have had about Hurricane Gloria just recently have, I believe, enabled us to save a lot of lives a couple of weeks ago because a lot of people took preventive action.

Now, research would have to be organized in a direct and different way from organizations in other risks because there is no industry to do research and to make sure that it is done right, and in self-defense, as is done with toxic chemicals.

Decisions on managing the risks are going to be individual decisions of homeowners. A million or so decisions every year are going to be made about radon, not just one or two in the board rooms of chemical companies.

Now, although there should be further research of the health hazard itself, there should be more on the exposures and even more on the possible risk management options which are available. There should be research into the types of options which are available to the homeowner and not the types which are available to some highly informed person in the Federal Government.

I would support Dr. Cohen's comment that universities have a major role to play in that because, partially, they are educators and spread their knowledge as widely as possible, including among

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their students who are so often research assistants, and they go out widely and spread information.

Finally, I am going to make a suggestion of a possible research management tool. Since we know so little about how to predict where an exposure is—we cannot see a house; this is on the reading prong, therefore it is bad; this one is not on the reading prong, therefore it is good—I suspect we are eventually going to have to measure every house in the country.

A procedure that suggests itself is that, at the moment, measuring is as cheap as a termite inspection. Many States insist that when you sell a house, you have a termite inspection before you sell it and that termite inspection be available to the buyer and that it be a matter of negotiation between the buyer and the seller if and what you do anything about it.

If this were done for radon gas, have a possible radon gas inspection before selling a house, then you would get houses coming before the market at a slow, steady rate, and within 10 years we will have measured the lot, and the top 1 percent of those in which the hazard is bad will probably get reduced.

Thank you.

[The prepared statement of Dr. Wilson follows:]

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TESTIMONY TO BE PRESENTED AT HEARING ON "RADON CONTAMINATION - RISK ASSESSMENT AND MITIGATION RESEARCH", 2 P.M., OCTOBER 10, 1985. (Rayburn Building, Room 2325)

Committee on Science and Technology
US House of Representatives

by Richard Wilson
Mallinckrodt Professor of Physics
Harvard University

Mr. Chairman, honorable members of the committee, ladies and gentlemen; it is an honor to be asked once again to address a subcommittee of the committee on science and technology.

Before addressing the risks posed by radon gas itself, I would like to make a few historical comments about the way in which our general understanding of the subject has developed.

In early days of radiation protection the concern was primarily about external radiation sources - radiation from medical and industrial X-rays, and from various nuclear power sources. The only internal sources of concern were the ingestion, during the 1920's, of radium by those who painted luminous clock dials and sucked their paintbrushes.

In 1531 Paracelsus described a disease, which he called Male Metallorum, that existed among those who worked in the mines - particularly uranium mines. In 1879 Hesse identified it as lung cancer. Nonetheless, the dangers of lung cancer in uranium mines was widely ignored until the late 1960's, when numerous cases became evident. Although uranium mining up to that time was primarily for military purposes, this can be considered the one big safety mistake of those who planned the civilian nuclear power industry.

I shared in this mistake when I wrote a book on Energy and the Environment in 1974. I listed radiation hazards; I included hazards to uranium miners, but forgot the long term hazard of uranium mining tailings and I was therefore reproved by Professor Pohl of Cornell University. I then calculated that when added up over thousands of years it was one of the larger of the (small) hazards posed by nuclear power. But I also noticed that it was a small addition to an already large natural hazard.

In 1969/70 the Joint Committee on Atomic Energy held a number of hearings on the "Environmental Effects of Producing Electric Power". The 3 volumes of the hearings remained, for some years, a

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magnificent source of information on environmental matters. Many witnesses were concerned with the use of uranium mining tailings for building construction. Such misuse had resulted in unusually large external radiation levels in several places - particularly Grand Junction Colorado. Some of the more perceptive witnesses noted that homes built "on phosphate mine tailings" were likely to have radiation levels which were as high. The logical conclusion is that <u>any</u> hole in the ground is likely to be bad.

In 1973/4 when oil prices began to rise, and even more in 1979/80, strong efforts were made to conserve fuels. A part of this conservation was by redefining a life style to accept lower temperatures; a part by insulating buildings; but a part by reducing building ventilation. This latter action increased indoor air pollution in general and radon gas concentrations in particular, roughly inversely as the ventilation rate.

Already in 1974 some of us warned of the dangers; the increase even in <u>external</u> radiation levels would produce a risk that exceeded the risk of electricity generation by nuclear power; - even if we used the inflated risk figures of the Union of Concerned Scientists. But we were ignored because we were biassed "pronukes" and "obviously" (though unfortunately for my budget not in fact) in the pay of the industry.

We now know that with the best present calculations, with the usual assumption of low dose linearity, 5,000-20,000 lung cancers a year would have radon gas as a contributing cause. This makes radon the second largest source of environmental pollution, second only to cigarette smoking. The number exceeds the number of cancers reduced by all EPA actions to date.

Although some of us have been aware of this large environmental hazard, and have talked about it for over 10 years, few people heeded us. One reason may have been our alleged bias. There is also a further difficulty with facing the hazard: there is no one to blame and no one to sue. In our present litigous society there is only a small constituency in favor of safety under these circumstances. I want to emphasize here, however, that public health and safety are not achieved merely by blaming and suing. At one time earthquakes, tornados, and hurricane caused more problems than they do now. The excellent warnings about Hurricane Gloria and the preventative measures put in place illustrate that the death toll can be reduced in natural hazards. So let it be with radon.

We did make an error. 10 years ago I attributed high radon levels entirely to bad building materials and inadequate ventilation. As measurements (slowly) came in, we noted (sometimes with ill-concealed glee) that the highest levels were in solar heated houses - built by those who wanted to avoid the supposed risks of nuclear power. Crushed granite to absorb sunlight lets radon into

the house; inadequate ventilation keeps it there. Although some of the bad cases may have these as causes, we now know that the major problem is entry of radon gas into the house from below - the house acts as a funnel, sometimes at a lower pressure than the ground, sucking gas from below. The real hazards, then, are building on ground with high levels of radon, such as on a geological fault, and inadequate basement sealing.

The research on radon will have to be organized and directed somewhat differently than research into other risks. Industry cannot be expected to play an important part in "self-defense" as they do for toxic chemicals. Decisions on managing the risk are going to be personal decisions of home owners even more than is usual. Research on measurement and mitigation methods must concentrate on those methods that can most readily assist the millions of individual decisions that will have to be made.

There should be further research on the health hazard itself. At the moment the risk is based on the excess lung cancer incidence among miners of uranium ore in several countries; Europe, Canada and the USA. Although all studies agree that there is more cancer among the miners than in the population generally, there are considerable differences as to details. In general the US data show a smaller risk than the others. In the US, there is a difference between smokers and nonsmokers. Also there is a slight indication of a threshold at 200 Working Level Months (WLM) in a lifetime, below which there may be no effect. Perhaps in the European mines the dust may carry some other carcinogen, cocarcinogen or promoter which confuses the picture.

There are a significant number of houses where the measured radon levels exceed 20 pCi/l (0.1 WL) which is, after allowance for increased occupancy, about the occupation standard recommended by the International Commission on Radiological Protection (ICRP) and accepted by most nations. Above this level, the data on lung cancer among miners is statistically different from zero. The risk would seem to be determined directly by the data. Nonetheless, "pockets of lung cancer" have <u>not</u> been noticed in areas with high radon levels in homes. I commend a study of such effects to my epidemiological friends. Such studies should be undertaken with all the care usually done in epidemiology.

Exposure data is still sparse. The average concentration in measured houses is probably biassed towards high levels by the selection of houses for measurement. We still have no good way of guessing in advance which houses will have high levels. Everytime we have a general principle, something violates it. This year we heard about the "Reading Prong " where radon levels are high because of the glacial fault. But they are also high in Cumberland County PA, which is not on the prong.This meaans that we will need many more measurements - and perhaps <u>all</u> houses will eventually be measured.

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There needs to be research into the various risk management options. Some people want to make Pennsylvania a disaster area and make all houses with levels above a certain value eligible for federal funds. That is an option - but we should carefully study the effects of that option on the available resources and manpower. Moreover, since the measuring equipment must be left in place, a homeowner can "cheat" by keeping the monitor in the worst basement locations, thereby exagerating the average level to which he/she is exposed. Perhaps such an option could be available for the worst cases - such as those houses with over ten times the occupational level which is about 1% of all measured Pennsylvania houses .

The research on mitigation methods is in its infacy. My house is well sealed, and when my oil burner goes on in the winter, I can hear the door from the outside to the basement shut more tightly as air is sucked in. Presumably the partial vacuum sucks radon through the cracks (and it only needs 2% of total area to have cracks) in the floor. But also, it sends basement air with its radon up to the roof through the flue. Is the <u>net</u> result good or bad for the ground floor? Should I bring air from the outside for my burner preventing both effects? I don't even know the answer to this simple question and no one can tell me reliably.

Finally I would like to suggest a management tool. Measurements are now as cheap as a termite inspection. In many states the seller of a house must guarantee that it is free of termites by an inspection and pay to get rid of termites. I suggest that, similarly, a radon gas measurement accompany every house sale. The seller would be required to reduce the level to below (for example) 70 pCi/l - four times the occupational standard (corrected for occupancy). This would eventually result in all houses being measured and in mitigating steps being taken, at a steady rate, in the per cent or so of houses where the radon level is too high.

Such a procedure would put the onus on the home-owner, where it belongs, and government research should then be directed toward providing him/her with reliable information.

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Mr. SCHEUER. Thank you very much, Dr. Wilson.
Dr. Harley.

STATEMENT OF DR. JOHN H. HARLEY, NATIONAL COUNCIL ON RADIATION PROTECTION AND MEASUREMENTS

Dr. HARLEY. Thank you for this opportunity.

I am appearing today as a representative of the National Council on Radiation Protection and Measurements. This is a nonprofit group chartered by Congress back in 1964 to collect, analyze, develop, and disseminate in the public interest information and recommendations about radiation protection and measurement.

Last year, the NCRP published their Report No. 77: Exposures from the Uranium Series, with emphasis on radon and its daughters. This report summarized our knowledge on the subject and recommended that a radon daughter product concentration of 2 WLM per year be used as a guide for remedial action.

This recommendation was based on a risk analysis for exposure developed in NCRP Report No. 78: Evaluation of Occupational and Environmental Exposures to Radon and Radon Daughters in the United States.

The major conclusion from this latter report that we used was that the continuous exposure to 1 WLM per year would give a lifetime risk of excess lung cancer of about 1 percent in the population. This would estimate, then, a lifetime excess lung cancer risk of 0.2 percent for what we consider the average U.S. exposure of 0.2 WLM per year, and a risk of 2 percent for the recommended limit of 2 WLM.

Now, you should compare this with a lifetime risk, mortality risk for lung cancer in nonsmokers of about 1 percent, and in smokers of about 10 percent. You can find a detailed discussion of all of this in the written testimony.

The first point I would like to emphasize is that when we wrote this first report, we had very little data to estimate the average exposure and the distribution. We have more now, but it is still not adequate to give a reliable description, and we need a well designed national survey to furnish the necessary information.

My second point may be more important, and that is that there is a distinction between radon daughter products as a general health problem for the public and as a local problem involving individual members of the public. The former depends only on the average exposure in the United States. Any reduction in the population risk would require reducing the average exposure across the country, a very formidable task.

To look at individual exposures, you have to look at the distribution of exposures as well as the average. In table 1, I have shown a distribution—if you have the written material of my talk, on page 4—calculated distribution for the lifetime risk of death from lung cancer for a population of 1 million having an average radon daughter exposure of 1 WLM.

The main point is that if we assume this 0.2 WLM for the average exposure in the United States, two-thirds of the population would be in that group. Only about 1 percent would be above 1

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WLM. But then there are also numbers above 4 and above almost any number you could mention.

If you attach a risk factor to this table, you come up with a very interesting point, and that is that one-third of the lung cancer deaths occur in people that have less than the average exposure. Only about 10 percent of the lung cancer deaths from radon come from those above 1 WLM. So when you work on the individual, you are not helping the population.

If you saw the Times article mentioned by Congressman Ritter today, it mentions in there that the EPA would reduce the lung cancer deaths from radon by 35 to 50 percent. You realize that to reduce it by 50 percent, you must cut the average exposure in the United States in half, and you see what a task it is. This is entirely different than going to individual houses in the prong and getting them down below the sort of permissible level.

Thank you.

[The prepared statement of Dr. Harley follows:]

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Oral Testimony Prepared for Hearings before the

House Science and Technology Committee.

Distribution of Radon Daughter Risk in the United States

John H. Harley*

National Council on Radiation
Protection and Measurements

* Mailing Address
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Distribution of Radon Daughter Risk in the United States

My name is John Harley and I am appearing today as a representative of the National Council on Radiation Protection and Measurements (NCRP). The Council is a non-profit group, chartered by Congress in 1964 to collect, analyze, develop and disseminate, in the public interest, information and recommendations about radiation protection and measurement.

I have attached a CV to my testimony, but I retired five years ago as Director of the DOE Environmental Measurements Laboratory in New York. My 1952 doctoral thesis was on the subject of radon and I have been active in the field ever since- including the years since retirement. My wife also works in the radon field and we are involved in research as well as work for the NCRP.

Last year, the NCRP published their Report No. 77- Exposures from the Uranium Series with Emphasis on Radon and Its Daughters. This report summarized our knowledge on the subject and recommended that a radon daughter product concentration of 2 WLM/y be used as a guide for remedial action. This report was prepared by a committee which I chaired.

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This recommendation was based on a risk analysis for exposure developed in NCRP Report No. 78- Evaluation of Occupational and Environmental Exposures to Radon and Radon Daughters in the United States. The group preparing this report was chaired by Dr. Naomi Harley. The major conclusion used from the latter report was that continuous exposure to 1 WLM/y would give a lifetime risk of excess lung cancer of 9000 per million in the population. This would estimate a lifetime excess lung cancer risk of 0.2% for the assumed average U.S. exposure of 0.2 WLM and a risk of 2% for the recommended limit of 2 WLM/y. These values may be compared with lifetime mortality rates for lung cancer in the population of about 1% for non-smokers and 10% for smokers.

A more detailed discussion of these risk values may be found in the original reports, but my wife and I have prepared a summary which is attached as written testimony. The title is- Risk Assessment for Environmental Exposures to Radon Daughters, and it includes the assessments made by groups other than NCRP.

The first point I would like to introduce here is that in writing NCRP Report No. 77, we had very little data to estimate the average exposure and the exposure distribution for the United States. There are more data now, but still not enough to give a reliable description of population exposure. We need a well-designed national survey to furnish the necessary information.

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My second point is that there is a distinction between radon daughter products as a general health problem for the population and as a local problem involving individual members of the public. The former depends only on the average exposure in the United States and any reduction in the population risk would require reducing the exposure across the country- a formidable task.

To consider individual exposures, it is necessary to look at the distribution of exposures as well as the average. All of the radon daughter surveys have shown a so-called "log-normal distribution", which merely means that a relatively large number of exposures will be several times the average. This is illustrated in Table 1, which shows the distribution of natural background exposures assumed in preparing NCRP Report No. 77. The second column shows that over 1% of the population has exposures more than 5 times the average and over 0.1% has exposures more than 10 times the average.

If we now attach risk factors to these exposures, we obtain the predicted mortality in column 3, which is expressed in percent in column 4. This shows that one-third of the predicted mortality would occur in those that are exposed to concentrations below the average and only about 3% in those exposed to more than ten times the average.

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This illustrates my second point. Seeking out homes and individuals with high exposures and following up with remedial action will certainly reduce the risk to the individual. Since you cannot reduce the exposures to zero, the net effect may be less than expected. It must be clear, however, that the process of reducing a few individual exposures will do little for the general public health problem in the population.

In summary, I would hope that we will soon have an adequate national survey to determine the extent of the public health problem. In addition, it would be helpful to spend some effort developing cheap remedial action techniques suitable for country-wide use.

Table 1. Calculated distribution for the lifetime risk of death from lung cancer for a population of 1 million having an average radon daughter exposur of 1 WLM/y and a geometric standard deviation of 2.5.

Exposure (WLM/y)	% of Population	Deaths per Million	% of Deaths
<0.2	69.3	594	33.0
0.2-0.5	23.6	658	36.6
0.5-1.0	5.7	348	19.3
1.0-2.0	1.2	143	7.9
2.0-4.0	0.14	35	1.9
>4.0	0.01	22	1.2
Total	100	1800	100

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BIOGRAPHICAL MATERIAL

John H. Harley, retired director of the Environmental Measurements Laboratory (EML) in the U.S. Department of Energy. This laboratory was formerly known as the Health and Safety Laboratory (HASL) under the Atomic Energy Commission and the Energy Research and Development Administration.

Born: June 2, 1916 in Lafollette, Tennessee

Education:

Brown University	Sc.B.(Chem.)	1938
Rensselaer Polytechnic Institute	Ph.D	1952

Thesis-"Sampling and Measurement of the Airborne Daughter Products of Radon and Thoron."

Employment Background:

1938-40	Latex Development Chemist, U.S. Rubber Co.
1940-42	Graduate Student, Rensselaer
1942-46	Analytical Chemist, Union Carbide Research Labs
1946-49	Instructor/Asst. Prof., Rensselaer
1949-60	Chief of Analytical Branch, Health & Safety Lab of the Atomic Energy Commission
1960-80	Laboratory Director, Health & Safety Lab, later Environmental Measurements Lab of the Department of Energy

Publications: about 100 articles and reports in the fields of analytical chemistry, measurement of radioactivity, weapons test fallout and environmental contamination.

Present Activities:

Honorary member, National Council on Radiation Protection. Active member 1974-84, also on Board of Directors until 1984. Chairman of Committees producing reports "Natural Background Radiation in the United States" in 1975 and "Limits for Environmental Radiation Exposures (Uranium Series)" in 1984. Consultant to two other committees and chairman of committee to revise the natural background report.

Advisor, U. S. Delegation to the United Nations Scientific Committeee on the Effects of Atomic Radiation since 1956. Have been active in producing their comprehensive reports issued in 1958, 1962, 1964, 1966, 1969, 1972, 1977 and 1982.

Adjunct Professor, Institute of Environmental Medicine, New York University School of Medicine.

Consultant on legal cases involving environmental contamination by natural and artificial radionuclides.

Active participation in research on the measurement of radon and its daughter products in the environment.

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Presented as the written testimony of
John H. Harley before the House Science
and Technology Committee.

Risk Assessment for Environmental Exposures to Radon Daughters

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ENVIRONMENT INTERNATIONAL- In Press

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ABSTRACT

Predicting the consequences of population exposures to radon daughter products is based on experience with the high exposures and high exposure rates of underground miners. Since lung cancer, the expected consequence of exposure, develops late in life, the total mortality has not been completely expressed in the various mining groups. While there is general agreement on the lung dosimetry, predictions of lifetime risk by current models vary significantly. The need for a satisfactory model is great since average lifetime environmental exposures are about one-tenth those shown to have caused excess lung cancer in miners. The present paper reviews the published approaches to this modeling.

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Risk Assessment for Environmental Exposures to Radon Daughters.

As with many other scientific problems, there is insufficient information to make a definitive assessment for the risk of lung cancer from exposure to radon daughter products at environmental levels. On the other hand, it is necessary to present our best estimate based on our current state of knowledge. This paper will attempt to summarize the substance of two reports of the National Council on Radiation Protection and Measurements (NCRP 1984a; NCRP 1984b) and to compare the risk estimates in the former report with other published values.

The available data on exposures of underground miners to radon daughter products are in terms of the Working Level (WL) and Working Level Month (WLM) - units designed to account for the lack of equilibrium between radon and its daughter products. The WL is defined as- any combination of short-lived radon daughters in 1 liter of air that will result in the emission of 1.3×10^5 MeV of potential alpha energy. The WLM results from inhaling an average concentration of 1 WL for a working month of 170 hours. The annual exposure of a miner, at a concentration of 1 WL, would be 12 WLM, while continuous exposure of a member of the population would give about 50 WLM. The SI units for concentration is the Joule per cubic meter ($1\ J/m^3 = 5 \times 10^4$ WL) and for exposure is the Joule-hour per cubic meter ($1\ Jh/m^3 = 200$ WLM)

Two factors appear to be unquestioned. First, the excess lung cancer mortality in several groups of underground miners exposed to radon daughters with different other potentially toxic materials fixes the etiological agent. This is confirmed by the qualitative dose-response curves for several groups. Second, an excess of lung cancer appears with total exposures of less than 100 WLM, while the average environmental exposure in the United States has been estimated as 0.2 WLM/y, giving 10 WLM in 50 years. Thus the extrapolation from levels showing effects to the levels of interest is only an order of magnitude.

The other factors entering into the risk assessment are open to some question. They will be listed here, then treated briefly in the rest of the paper.

1. The exposure data on the mining groups is poor, particularly for the earlier periods of mining history.

2. None of the mining groups approach closure- that is all members dead from lung cancer or other causes. This means that total lung cancer mortality must be predicted from the present data.

3. The mining populations are small, and it is not possible, at present, to combine the groups.

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4. While lung cancer from smoking does not perturb the data from high exposures, it can have some effect on the low exposure mining groups and definitely affects the control populations.

5. The alpha dose to bronchial cells appears to be the relevant quantity, but calculation of an exact dose requires more information on exposure conditions than the simple comparison of WLM exposures with effects.

6. The data on environmental exposures are still too scattered to give the necessary information on distribution. This limits our ability to carry out useful epidemiological studies on the general population.

The lack of past exposure data cannot be remedied and the effect can only be softened by the various means of reconstruction that have been used. Present mines are mostly in different ore body geometry, the dust loading is different qualitatively and quantitatively, and the ventilation and other controls have changed markedly.

In the United States, there seem to have been two sets of data, one produced by the mine operators and one produced by the mine inspectors. Not surprisingly, the latter tend to be higher as the inspectors seek out areas of high exposure. These higher values were used in the dose-response work for the U. S. groups and may contribute to their lower cancer/WLM ratio than the ratios for other groups.

The prediction of future lung cancer deaths in the present miner populations generally reduces to the question of relative risk vs. absolute risk models. This is a matter of formalism since neither the present status of the epidemiology nor our knowledge of the relevant physiological processes is adequate for making a selection. Thus we are reduced to mathematical exercises based on the interpretation of partial data.

The absolute model gives a constant risk per unit exposure for each year of life. The relative risk model gives a mortality per unit exposure that is a fixed percentage of the lung cancer mortality in the selected population at any given age. For lung cancer, this means that the attributable risk rises with age up to perhaps 90 years. Both models require correction for life table statistics, allowing for competing causes of death. At closure, of course, the true mortality will be known and it would not be surprising if the data do not fit either model.

The relative risk model predicts an increase in annual attributable lung cancer mortality with age, following the general pattern of age-specific lung cancer. It should be noted that some of the studies are showing a possible decrease in attributable lung cancer mortality as the groups age. This further calls into question whether we have adequate data for selection of a risk model.

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The model in NCRP Report No. 78 (NCRP, 1984a) is a modified absolute model that includes an empirically determined exponential factor for disappearance of the risk with age. It also considers the normal time to appearance of lung cancer with an age threshold of 40 years. The total lifetime cancer mortality predicted for the total population is similar to that with a relative risk of 0.3%. It also predicts a lung cancer mortality for average population exposures that is about 1/4 th of that expected for non-smokers. This seems reasonable but can only be considered as slight confirmation of the overall risk estimate, not of the model.

The most useful description of the lung cancer risk from exposure of a population to environmental levels of radon daughters is the lifetime risk of mortality for an exposure from birth to 1 WLM/y. This risk may be calculated by any model desired but must be developed for the age structure of the population and include a correction for competing causes of death. In addition, the calculated risk must predict a reasonable mortality both for non-smoking members of the population and for those exposed to elevated natural levels of radon daughters.

Epidemiological studies of the population are not presently adequate to give firm risk estimates and we are required to use the available data for miners. These groups have been exposed at different rates, at different ages and usually have poor histories of smoking. Since none of the populations have reached closure, lifetime risks are not known and the best approach to a common description of exposure as a basis for risk projections has been the observed annual lung cancer mortality per WLM exposure. This is usually expressed as the lung cancer deaths for one million person-years at risk per WLM. Most of the available data are for mean WLM exposure and total years at risk, from start of exposure to death or the year of the study, for a miner group or sub-group. More detailed calculations could be made from a complete record by individual but this might not improve our estimates.

The available data were presented in NCRP Report No. 78 (1984a) and the figure is reproduced here as Fig. 1. While considerable attention was paid to checking the person-years at risk in this report, the same data were available to all of the groups publishing risk estimates.

The risk estimates selected and projected in the various reports are summarized in Table 1. These values are not always strictly comparable and the following text should be considered in conjunction with the Table.

The estimates made in the various reports differ in the miner groups selected. For example, BEIR III (NAS, 1980) selects the Czech and Newfoundland groups to give a value of 19 deaths per year for 1 million persons exposed to 1 WLM, while NCRP used the average of all the data, 12, which was rounded to 10 in their calculations. BEIR III also developed an age dependent risk of 10 for those 35-49

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at time of diagnosis, 20 for those 50-65, and 50 for those over 65. These were supposedly derived from the original data of 9 for those who began mining before 30, 13 for those who began at 30-39 and 47 for those that began at 40 or older. Report 32 of the International Commission for Radiological Protection (ICRP, 1981) selected 5-15 as the most probable range for occupational exposure from the overall range of 2-20 that they considered. They also calculated a risk range of 150-450 per million exposed to 1 WLM for a 30-year expression period.

Other groups looked at the total mortality over many years. UNSCEAR (1977) used earlier Czech data on the cancer expression over a 20-year period of 230 per million WLM and multiplied by 2 to estimate a total expression of 450 for a remaining lifetime of 40 years. They indicated that a representative annual risk would be in the range of 5-10 per million for 1 WLM exposure. Thomas and McNeil (1982) estimated a lifetime risk based on a relative risk model that discarded the U. S. miner data. The Environmental Protection Agency (EPA) also used a relative risk model to project a lifetime risk of 860 (EPA, 1979), later reduced to a range of 300-700 (EPA, 1985). They also calculated a lifetime risk of 730 from the BEIR III age-dependent annual risks and a value of 600 for a U.S. analog of the Thomas and McNeil data. These values must be approached with caution, however, since EPA has redefined the WLM for their own purposes.

Most of these estimates are based on exposures of adult male miners during partial or complete working lifetimes and give either the annual or total risk of lung cancer mortality during their remaining life.. Projections of these values to the desired lifetime risk of lung cancer mortality for exposure from birth to environmental levels of 1 WLM/y is an added step that can also cause problems. The EPA relative risk model projects a range of 32,000 to 70,000 lung cancer deaths per million. This may be compared with the NCRP (1984a) projection of 9000 with a modified absolute risk model.

The total exposed mining population is small and additional cohorts are unlikely to be found. The age structure and exposure data of the groups differ widely so that the analyses are necessarily fragmented at present. This means that we should look at possible epidemiological studies of general population groups. The available data on exposure are not adequate to plan such studies for the U. S., but Letourneau et al (1983) in Canada and Edling et al (1985) in Sweden have carried out preliminary studies with conflicting results. Case control studies that are in progress in Canada should give more definitive information.

Smoking is not a confounding factor in the miner studies with high exposures. It can contribute to the confusion with low exposures and with control populations. Also, it would appear that smoking histories are no better documented than those for radon daughter exposure. Most studies only classify individuals as smokers or non-smokers and further breakdowns are purely arbitrary.

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Whittemore and McMillan (1983) did formulate the two risks for U.S. miners as,

$$\text{Relative Risk} = (1+0.0031 \times \text{WLM})(1+0.00051 \times \text{Packs of Cigarettes})$$

where WLM and Packs of Cigarettes were total exposures up to 10 years before the current age.

It would seem logical that the best dose-response function would be developed by comparing the calculated alpha radiation dose to the relevant tissue or cells with the observed effects. Actually, the various dose calculations for a given depth in bronchial tissue are in reasonable agreement, but an exact calculation requires additional data on characteristics of the inhaled aerosol that are not needed for WLM exposure estimates. Thus the dosimetry is most valuable for comparing the expected dose for different exposure conditions or for different physiological conditions. The NCRP Report No. 78 (NCRP, 1984a) calculations indicate a rather narrow range with age in the population and a value for miners that is very similar to the population average for environmental exposures.

Another question that arises with population exposures to radon daughters is that of linearity in the dose-response curve. There is general agreement that alpha response is more likely to be linear than linear-quadratic, so linear extrapolation from the miner data is generally practiced. This is particularly apropos for the short range of extrapolation needed. Some investigators, however, propose that supra-linearity exists- that is the effects are more serious than predicted by linear extrapolation. This does not appear to be a large effect but it cannot be ruled out completely.

The contrary question, that of a threshold or a practical threshold is not of real concern in the modelling, but could be significant for population exposure if it exists. Proof of a threshold is just as unlikely for attributable lung cancer as for other radiation effects.

NCRP Report No. 77 (NCRP, 1984b) gave a recommendation that remedial action was desirable for exposure of an individual to radon daughters above 2 WLM/y. The reasoning behind this recommendation was spelled out carefully in the report. This level of exposure from birth would lead to a calculated lifetime risk of about 2% of developing attributable lung cancer. It was stressed that any individual was free to reduce his or her exposure further. Further, no distinction was made between natural and artificially enhanced sources of radon daughters.

In the absence of adequate data, it was assumed that the average natural exposure in the United States was 0.2 WLM/y and that this exposure was log-normally distributed with a geometric standard deviation of 2.5. This would mean that about 0.1% of the population is exposed above the NCRP recommended limit for remedial action. Of

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course the data are too limited to actually define the distribution and most of those above the limit will never be aware of their potential risk.

Table 1. COMPARISON OF RISK ESTIMATES

Source	Risk per WLM for 10 PY	Period of Expression	Risk/WLM During Expression Period	Relative Risk	Lifetime Risk for 1 WLM/y
NCRP (1984a)	10	Remaining Lifetime	200	-	0.9%
UNSCEAR (1977)	5-10	40 y	450	-	-
ICRP 32 (1977)	5-15	30 y	150-450	-	-
BEIR III (NAS, 1980)	10-50 (a)	Remaining Lifetime	730 (b)	-	-
EPA (1985)	-	Lifetime	300-700	1.2-2.8%	3.2-7.0% (c) 1.3-2.8% (d)
Thomas & McNeil (1982)	3-18	-	600 (b)	2.3%	2.0%

Notes:- (a) According to age.
(b) Calculated by EPA.
(c) EPA WLM.
(d) Standard WLM.

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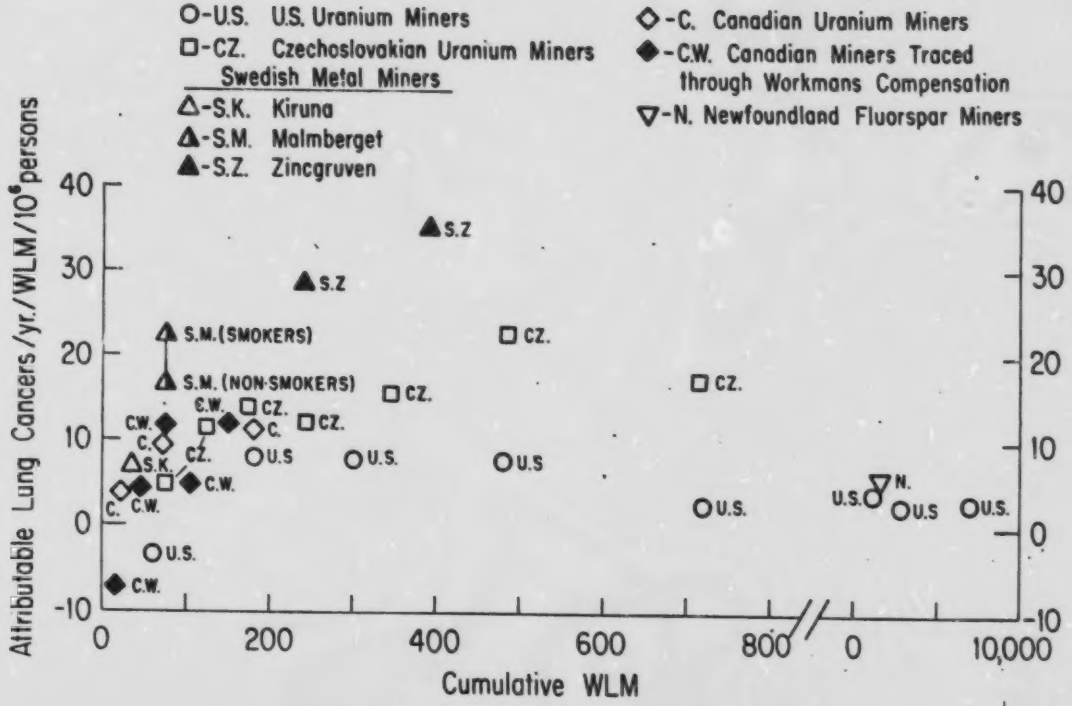

Figure 1. Attributable annual lung cancer risk as a function of cumulative exposure (NCRP, 1984a)

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Mr. SCHEUER. Dr. Harley, thank you very, very much.
Dr. Nero.

STATEMENT OF DR. ANTHONY V. NERO, JR., BUILDING VENTILATION AND INDOOR AIR QUALITY PROGRAM, LAWRENCE BERKELEY LABORATORY

Dr. NERO. I would like to thank you, Mr. Chairman and members of the committee, for the chance to come again before this committee, this time to talk about indoor radon in particular.

I would like to make basically three points having to do with what we know about indoor radon, what we have to do, and something about a perspective on this problem.

As indicated by many of the people here before me, we know a great deal about indoor radon. We know that in single-family houses, the average concentration is probably in the vicinity of 1½ picocuries per liter.

Mr. SCHEUER. One-and-a-half what?

Dr. NERO. Picocuries per liter, which is the equivalent of about or somewhat less than about 0.01 working level, just to give you a translation.

We also know, based on an analysis performed by our group and that has been cited over and over again in newspapers such as the New York Times article, that something on the order of 1 million homes probably need remedial action, if you take as a remedial action level something in the vicinity of the level recommended by the NCRP.

Now, that is just an estimate. It was not based on a statistically representative national survey, but it is based on 20 or 30 surveys taken around the country, and if so, a million homes is going to be a lot of trouble. If you choose a lower level, you are going to have a lot larger number of homes to deal with.

There are some other important things that we know. We know where radon comes from, and we have a pretty good idea of how to deal with it in a home where it is found to be at a high level.

We also know that this problem did not come about because of this country's energy conservation problem. It came about because we live in houses.

Well, the question now is what do we do about it. The fact is that a good deal of research has already taken place on indoor radon over the last decade or so. But more research needs to be done in all of these areas in characterizing concentrations, in characterizing sources, in how radon gets in, in looking at the behavior of radon decay products, in looking at the epidemiology of radon.

What has been done so far has been done largely with funding from the Department of Energy and also from the Environmental Protection Agency. But what has been done, if you consider the scope of this problem, has been done on a shoestring.

As a representative and in fact a person responsible for one of the larger, well established groups on indoor radon, I can speak personally and say that there has been extreme difficulty in getting even enough funding to support three or four people on a research program on indoor radon over the last 5 years. This problem actually extends to the general area of indoor air quality.

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In contrast, consider something like the question of uranium mill tailings, where a principal concern is the emission of radon from those mill tailings. The Government has allocated on the order of a billion dollars to that problem. But the indoor radon exposures of this country are probably 10,000 times or more times what comes from the uranium mill tailings problem.

In terms of what to do, probably the most important thing to do is to formulate a reasonable overall strategy for the control of radon, which includes some selection of guidelines for when we do things, how rapidly we do them, and so forth, a program for identifying areas of the country that have excessive indoor radon levels, and a strategy in individual homes for selecting the most cost effective and effective means for reducing radon concentrations.

But what I would like to close with is a little bit of perspective. Other people testifying have touched on this. People are often concerned with environmental exposures that cause lifetime risks to the individual, risks of premature death of the order of 1 in a million or 1 in 100,000.

But as we have seen here, in the case of radon, even the average exposure has a risk associated with it that is estimated to be a quarter of a percent, and there are houses where the risk is 20 percent or even higher. We are talking about things that are 1,000 or 10,000 times the normal environmental questions that we deal with.

But we have to realize also that we as living people make decisions that cause risks in this same range. By getting into your car over and over again in your lifetime, you are incurring a risk of premature death of the order of 1 percent. Similarly, accidents in your home cause a risk in the same range.

If you want a large risk, talk about smoking. But it is important, very important, to maintain some perspective in this.

Further, however important one considers a case like the Reading Prong, one has to realize, as indicated by other speakers, that the Reading Prong, however difficult and important the problems are there, represents only a small fraction of the problem of radon in this country.

Thank you, Mr. Chairman.

Mr. SCHEUER. Repeat that last little bit.

Dr. NERO. I say, however important we take the case of the Reading Prong to be, we have to realize that that represents only a small portion of the indoor radon problem in this country. And, furthermore, we have to realize that there is no need to panic. One can have a sense of urgency without causing panic either in the Federal sector, among States or among individuals, and it is important to realize that.

The fact is we have been living with radon for all of our lives, and even if you live in a high radon house, with very few exceptions, one has to realize that living in it for another year or so is not going to incur a very substantial risk.

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Hence, although we have an important problem here and one that really deserves many more resources than have been allocated to it in the past, it is a problem that we can deal with and deal with effectively, but we do have to deal with it with some urgency.

Thank you.

[The prepared statement of Dr. Nero follows:]

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WHAT WE KNOW ABOUT INDOOR RADON

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Testimony prepared for Hearings on
"Radon Contamination: Risk Assessment and Mitigation Research"

Held by

the Sub-Committee on Natural Resources, Agriculture Research and Environment
Committee on Science and Technology
U.S. House of Representatives

October 10, 1985

I. Summary

II. Indoor Concentrations of Radon 222 and its Daughters: Sources, Range, and Environmental Influences

III. List of Radon Publications from Lawrence Berkeley Laboratory

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I. SUMMARY

A decade ago, U.S. researchers began to investigate the possibility that airborne concentrations of radon and its decay products inside homes might be high enough to have significant health implications. Preliminary work quickly revealed that indoor concentrations of radon were typically in the vicinity of 1 pCi/l and that a surprising number of homes had levels that were considerably higher. Naive application of the health effects data from underground miners - who were found to have unusually high rates of lung cancer due to exposure to radon decay products - indicated that indoor radon might be the cause of thousands of cases of lung cancers per year in the general population of the United States, and that people living in houses with high concentrations suffered unusually large individual risks.

These preliminary indications have stimulated substantial research on indoor radon, with a major degree of support coming from the U.S. Department of Energy, which wanted to investigate the extent to which energy-saving measures in buildings - and specifically those aimed at reducing the ventilation rate - might raise levels of indoor pollutants. A significant but smaller amount of research on radon has been supported by other agencies, particularly the U.S. Environmental Protection Agency. The results of research over the last decade have given us a much more complete picture about the sources, occurrence and behavior of indoor radon, so much so that it is distressing to hear public pronouncements that we don't know very much about indoor radon. The fact is that we know a great deal. The principal thing we do not know has to do with the practical questions of how to extend our knowledge to actually identifying and reducing excessive concentrations in individual homes or areas through the United States. And even about this, we know a lot.

1. What we know and what we don't know.

We now have very substantial information about the concentrations of radon that exist in homes (specifically single-family structures), including a quantitative appreciation of the fraction of homes with high concentrations. Equally important from a practical point of view, we have achieved a substantive understanding of the factors that affect indoor concentrations, the most important being the radon entry rate for individual houses or classes of houses. Related to this, our understanding of how to reduce excessive concentrations has grown very rapidly, putting us in a good position to begin testing effective strategies for limiting radon concentrations in the U.S. housing stock. The reason for doing this is, of course, the health risk associated with indoor levels. Our understanding of lung cancer risk has also advanced considerably, primarily as a result of recent examinations of how to apply existing dose-response data to estimate the health effects from indoor exposures to radon decay products. It now appears that in approximately a million houses, occupants are receiving exposures comparable to or exceeding those received by underground uranium miners and that long-term occupants of these houses suffer added individual risks of lung cancer of 2% or more, ten thousand times larger than some environmental risks that currently

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receive substantial regulatory attention.

Given all that we know, the incentives for reducing these concentrations are clear, but - as indicated below - we know the basic elements for achieving this objective, but not enough about how to put them together. Formulating a strategy for controlling excessive concentrations requires three obvious components: selection of levels of concern; development of techniques for identifying areas and individual homes with excessive levels; and a decision structure for choosing appropriate control techniques for any specific house. Just as important, it requires some allocation of responsibility - scientific, administrative, and ultimately, financial - for implementation of a strategy. And, although even here we know the principal actors - the federal government, professional organizations, state and local agencies, and individual occupants - we are only now learning how to allocate effectively the burden of solving the problem of indoor radon.

2. Distribution of radon concentrations in U.S. homes

We now have in hand, some dozens of radon data sets resulting from indoor monitoring in various areas of the country. Approximately 20 of these data sets were acquired simply to determine, by survey, what concentrations were, without any prior indication that levels might be unusually high; typically, these studies were conducted in connection with energy-conservation programs. These studies provide a basis for a statistical analysis of indoor radon concentrations. The principal results of such an analysis are the following: 1) that the average radon concentration in single-family homes is approximately 1.5 pCi/l (equivalent to approximately 0.007 WL of decay products), and 2) that the distribution of concentrations has a long tail to very high concentrations with 1-3% of single-family homes having annual-average radon concentrations of 8 pCi/l or more. (A number of studies also indicate the occurrence of levels higher than 100 pCi/l, but - because these occur primarily in studies where high levels were expected - they provide no basis for estimating the frequency of such levels in the housing stock as a whole.) The fraction of houses found to exceed 8 pCi/l is the origin of the estimate that in approximately a million homes exposures are comparable to those in uranium mines. Making certain assumptions, we can also infer that - in these homes - exposures equal or exceed the 2 WLM limit above which remedial action is recommended by the National Council on Radiation Protection and Measurements.

3. Risk of lung cancer

During the last three or four years, several research groups in the United States and Europe have examined the question of how to utilize the lung cancer data from miners for estimating the risk from environmental exposures to radon decay products, primarily those occurring indoors. The dose models used by these groups take account of differences in conditions in mines and in homes - specifically with respect to such factors as breathing rates, age of individuals exposed, particulate concentrations in the air, and the details of deposition and radiation exposure in the lung. The results of these

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studies indicate that the dose-response data from the miner studies can be applied fairly directly to indoor exposures.

Estimates based on these results indicate that lifetime exposure to the decay products associated with indoor radon concentrations of 1 pCi/l causes an added risk of lung cancer of about 0.25%. Considering our knowledge of indoor concentrations, this would imply that radon indoors causes 5,000-10,000 cases of lung cancer per year in the United States. Furthermore, the risk is proportional to exposure, so that applying this dose-response factor to those living in houses with 8 pCi/l or more of radon yields individual risks for long-term occupants of 2% or more. It is important to note that, at such high exposure levels, a directly observable increase in lung cancer rates occurred among miners. Thus, unlike other estimates of risk from environmental pollutants, no extrapolation is required at these exposures, and - even for average exposures, those associated with 1.5 pCi/l or so - a relatively small extrapolation is involved. The size of these estimated risks, either for the average exposure or for homes in the high-concentration tail, is unusually large by comparison with risks associated with other environmental pollutants.

4. Sources and other factors affecting indoor concentrations

For radon and its decay products, as for other indoor pollutants, the indoor concentration is affected by three overall factors: the rate of entry into the indoor environment, the rate at which indoor air an outdoor air are exchanged by ventilation, and the rates of decay or reaction with other pollutants or with walls and furnishings. A principal result of radon research of the last decade is that the main cause of the wide distribution of indoor concentrations is variability in radon entry rates, and particularly the degree to which radon enters homes from underlying or surrounding soil and rock. As a result, high indoor concentrations are usually associated, not so much with low ventilation rates, as with high rates of radon entry through the understructure. This is not to say that changing the ventilation rate will not change the indoor concentrations, but rather that in any sample of the housing stock, the dominant influence on concentration is the source factor. (The entry rate is actually found to have an <u>indirect</u> connection with ventilation: radon enters homes primarily via air that is drawn from the soil by small pressure differences between the house and the ground, and pressure differences across the house shell are also the cause of air infiltration, the principal contributor to ventilation for most homes.)

In addition to sources and ventilation, the physical and chemical reactions of the radon decay products can have a substantial influence on indoor airborne concentrations. Typically, the decay-product concentration (averaged with the standard weighting) is about half of the radon concentration. And, although this ratio can vary considerably, the average ratio of 0.5 still provides a reasonable basis for concentration estimates. Perhaps more important, we have come to realize that the radiation dose to the lung from the radon decay products can be affected significantly by the concentration of airborne particles indoors, and that - in particular - cleaning of the air by filtration or other means may reduce the overall decay-product

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concentration, but - because of a resulting shift in the degree to which decay-products are attached to particles - may not reduce the radiation dose.

5. Control techniques

Methods for controlling indoor radon concentrations parallel our understanding of the dependence on entry rates, ventilation rates, and reactions. Because differences in entry rates are the principal influence on concentrations, reduction of entry rates also offers the most effective means for reducing excessive levels, once they are found. This can, in principle, be accomplished by removal of the source material, by sealing the understructure, or by reducing the entry of air that is driven by the small pressure differences mentioned above. For most cases, it appears that this last approach can bring about the most dramatic reduction of indoor radon concentrations, relying principally on inexpensive piping and small fans to reverse the pressure difference that would ordinarily draw radon into homes.

In some case, often as a temporary measure, we can also increase the ventilation rate to remove radon that has already entered the home. However, this approach has substantial limitations, since often one is seeking a dramatic reduction in indoor concentrations, which is not often practically accomplished by increased ventilation. Furthermore, although one can reduce the radon decay-product concentration by various air-cleaning methods, as suggested above this may not bring about a corresponding decrease in the radiation dose. Overall, then, it appears that attention to the sources should usually be the principal means for reducing indoor levels, but that in some cases increased ventilation may be suitable, particularly as a temporary measure.

6. Strategies for locating and reducing excessive concentrations

We, therefore, have substantial knowledge about radon, including its sources, levels, health risks, and control techniques. This knowledge does not, of itself, constitute an effective strategy for control. Thus, if faced with a particular house having high concentrations, we are able in principle to reduce the indoor concentrations to any specified level, as long as it is above the outdoor concentration. However, it is quite another thing to have 1) criteria for determining what constitutes "excessive", 2) an efficient method for finding the houses exceeding our criteria, and 3) a plan for choosing in each case an effective (and cost-effective) approach for control. Even more delicate is the matter of assigning responsibility for these matters.

We have, of course, made significant progress in each of these areas. For example, there is a growing understanding that dealing with some 80 million indoor environments, most privately owned, requires a structure of guidelines that deals in a suitable way both with the question of the average population exposure and also with the high levels that are now being found so frequently. The question of average concentrations can be handled quite effectively by standards

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or guidelines that directly address the issue of ventilation rate and that therefore indirectly assure that, in the absence of unusually large sources of any indoor pollutant, the indoor concentration will be in the normal range. On the other hand, protection of the individual from high levels can be accomplished by a remedial action guideline such as that recently recommended by the NCRP; this, in effect, provides a criterion for how much of the long high-concentration tail we should worry about. With respect to the question of responsibility for choosing these guidelines, it is clear that this can most effectively be done at the national level, and this is occurring.

As for identifying areas and individual houses where remedial action is necessary, we can use both monitoring and source-related information as a guide. Presently, our abilities to monitor the indoor concentration are most highly developed. On the other hand, because radium content and permeability of the soil are the principal determinants of the entry rate, examination of these parameters may lead to a more efficient way of identifying areas in which high concentrations are likely to occur, after which individual houses requiring remedial action can be identified by monitoring. Presently this is the principal area in which our actual knowledge is deficient. We do not yet know where high levels occur, except to the degree that we have happened on them, largely by chance. Identifying such areas efficiently will require an organized effort on a national scale, after which local entities in areas found to have a high radon potential can organize the search for houses with excessive levels, presumably with the active involvement of the residents in the area.

Once a house is found to have unacceptably high levels, we have the means of control suggested above. Although not yet available in an organized way, specific strategies for choosing and applying individual techniques are developing as our experience with mitigation grows. We can expect that, before long, this experience will be organized into a generally available body of knowledge. But this will not occur instantly or easily. Nor, I think, will the question of how to encourage or finance the actual implementation of remedial action measures, presumably the responsibility of the homeowner, be solved easily or immediately.

7. Attachments

Part II of this testimony is a more detailed paper indicating the current state of knowledge on radon sources, levels, behavior, and control techniques.

Part III provides a listing of papers reporting research on radon performed by the group at Lawrence Berkeley Laboratory. This is to demonstrate that, as a result of research of the last decade, a great deal is known, as indicated by the work of only one of the research groups active in this area.

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INDOOR CONCENTRATIONS OF RADON 222 AND ITS DAUGHTERS: SOURCES, RANGE, AND ENVIRONMENTAL INFLUENCES

Anthony V. Nero, Jr.

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INTRODUCTION

The radiation dose from inhaled daughters of ^{222}Rn constitutes about half of the total effective dose equivalent that the general population receives from natural radiation. A variety of results from the United States suggests that ^{222}Rn concentrations in residences average about 1 pCi/l (37 Bq/m^3). Estimation of the incidence of lung cancer due to the daughters associated with this much ^{222}Rn yields thousands of cases per year among the U.S. population.

It is also clear that indoor levels are sometimes an order of magnitude or more higher than average: it is the common experience of the community performing measurements in homes that ^{222}Rn concentrations in the range of 10 to 100 pCi/l occur with startling frequency. And, whereas the risk associated with even 1 pCi/l is very large compared with many environmental insults of concern, living for prolonged periods at the higher concentrations observed leads to estimated individual lifetime risks of lung cancer that exceed 1%. For the extreme concentrations that have been found, risks appear to approach that from cigarette smoking.

Not surprisingly, the early work on indoor concentrations has given rise to a broad range of research characterizing ^{222}Rn and its daughters indoors. This work has included significant monitoring programs in homes (although, as noted below, not in a statistical sampling of U.S. homes), investigation of the sources of indoor radon, examination of the factors affecting indoor concentrations, study of the behavior of ^{222}Rn daughters, and - of course - development of techniques to control indoor concentrations. In addition, radiobiologists and epidemiologists have begun to apply dosimetric and dose-response data to the problem of environmental exposures to daughters of ^{222}Rn.

The international research effort in this area has been very substantial, beginning in the 1970's. For detailed information,

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one must turn to the very large literature, which has - for example - recently culminated in two substantial collections of research papers on indoor radiation exposures (1,2). The purpose of the present paper is to distill the growing understanding of indoor concentrations and the factors - sources, ventilation rates, and daughter reactions - that affect them.

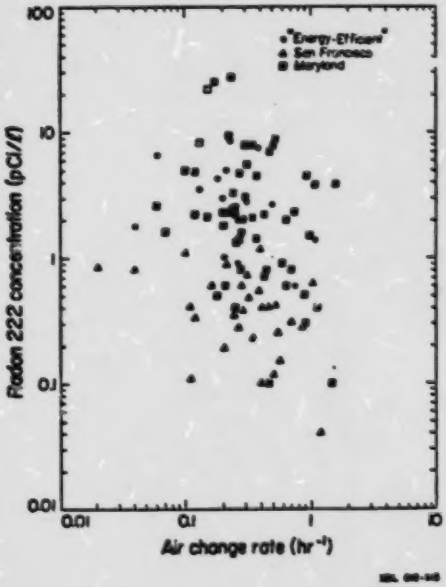

Figure 1. Radon Concentrations and Air Change Rates Measured in 98 U.S. Residences.

The results shown are from three survey groups: "energy-efficient" houses in the United States and (one) in Canada; conventional houses in the San Francisco area; and conventional houses in a community in rural Maryland.

OVERVIEW OF IMPORTANT FACTORS

The initial observation of significant concentrations of radon (taken to be ^{222}Rn unless otherwise stated) in ordinary U.S. homes (3) occurred at about the same time that programs to increase the efficiency of energy use were hitting their stride. Reducing ventilation rates in buildings can be a cost-effective, and hence attractive, component of such programs. However, given the expectation in first order that indoor pollutant concentrations equal the ratio of the entry rate per unit volume to the ventilation rate, energy-conservation programs were thought to have the potential to exacerbate the indoor air quality problem significantly. This expectation still has some merit, although -

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for every major class of airborne pollution from indoor sources - it has become clear that the presence or absence of substantial emission rates is the major determinant of whether or not a building has excessive indoor concentrations.

The importance of differences in source strength became clear in initial investigations of the dependence of indoor concentrations on ventilation rate. It was found that, with supply of differing amounts of mechanical ventilation in a given house, the indoor radon concentration varied as the inverse of the ventilation rate, as expected (4). However, at about the same time, paired measurements of radon concentration and ventilation rate in several housing samples showed no apparent correlation between these two parameters (5). As shown in Figure 1, for a given sample, the radon concentration and ventilation rates showed an approximately order-of-magnitude range; for the combined samples, the concentration showed a significantly larger variability than the ventilation rate, suggesting that the source strength was the dominant determinant of the wide range of concentrations observed in U.S. housing.

These indications have prompted substantial work in understanding the size and variability of radon entry rates, as discussed below. However, it is important to emphasize that other factors still play an important role: ventilation rates vary substantially within the building stock, which - after all - is one major incentive for instituting major energy conservation programs (the adjunct incentive being that the average ventilation rate in U.S. buuildings is rather high as compared with rates in some countries). And, even for a given radon concentration, the concentrations and physical state of the daughters - which account for the health effects of interest - can vary significantly.

It is worth noting at this point the substantial tendency of the research community to measure radon concentrations in survey efforts, rather than daughter concentrations. This tendency arises, of course, from the availability of a reasonably reliable and very simple integrating radon monitor (6), a significant contrast to the state of daughter monitoring. And yet, given a reasonable understanding of the relationship between radon and its daughters and an awareness of the fact that the daughter-to-radon ratio does not vary as widely as radon concentrations, measurement of radon concentrations is a reasonable indicator of daughter concentrations and is certainly a very effective tool in survey efforts. This is entirely analogous to the situation for many other pollutants: for example, although any health effects associated with NO_2 exposures may have a substantial dependence on peak (as opposed to average) concentrations, an integrating sampler can be a very effective survey instrument, provided associated studies examine relationships between average and peak concentrations under well-characterized conditions.

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As seen below, another incentive for emphasizing the radon concentration per se is that the very fact that this parameter shows the widest variability suggests clues to identifying and controlling excessive concentrations. Considering the origin of this wide variability, it will not be surprising that attention to radon sources and entry modes appears to have the greatest potential as a basis for control strategies.

SOURCES OF INDOOR RADON

Radon arises from trace concentrations of radium in the earth's crust, and indoor concentrations depend on access of this radon to building interiors. Radon can enter directly from soil or rock that is still in the crust, via utilities such as water (and in principle natural gas) that carry radon, or from crustal materials that are incorporated into the building structure in the form of concrete, rock, and brick. The relative importance of these pathways depends on the circumstances, but - for U.S. single-family homes - it has become clear that the first dominates the indoor concentrations that are observed.

Indications of this arose in early investigations, when it was found that measurements of radon emanating from structural materials could not account for observed indoor concentrations, based on estimates of the air exchange rate (3). A clearer picture emerged from the distribution of entry rates inferred from direct measurements of radon concentration and ventilation rate (such as those shown in Figure 1). Figure 2 shows such entry-rate distributions from various countries, as well as indicating the potential contribution of various sources. Although building materials were first suspected as the major source, based on experience in Europe (7), the initial U.S. results (5) strongly suggest that the soil must be the major source. Understanding how the rate of radon entry could be approximately equal to the unimpeded flux from the ground (i.e., in the absence of the house) has been a major focus of research on radon entry, both in the United States and Europe.

Soil and Building Material

Establishing a radon mass-balance for a building requires consideration of the various sources. As indicated in Figure 2, a median (or geometric mean) entry rate for U.S. single-family homes is in the vicinity of 0.5 pCi l^{-1} h^{-1} (18 Bq m^{-3} h^{-1}). Based on emanation rate measurements from concretes (17), one might expect emissions from this source to account for a median of about 0.07 pCi l^{-1} h^{-1}, far below the total observed. On the other hand, the potential contribution from unattentuated soil flux, a median of

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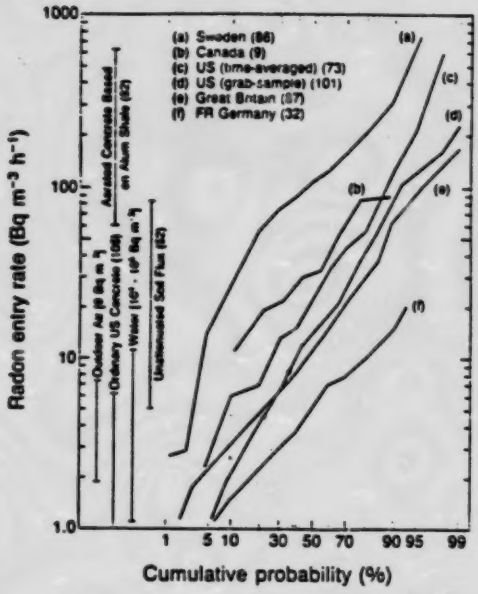

Figure 2. Cumulative Frequency Distributions of Radon Entry Rate Determined in Dwellings in Several Countries as the Product of Simultaneously-Measured Ventilation Rate and Radon Concentration.

The number of residences in each sample is indicated in parentheses; the sources of these results are a) (7), b) (8), c) (9, 4, 10-13), d) (5), e) (14), f) (15). The bars at the left indicate the range of contributions expected from a variety of sources, with assumptions indicated in brackets. For each source we have assumed a house having a single story of wood-frame construction with a 0.2-m-thick concrete-slab floor. The floor area and ceiling height are assumed to be 100 m^2 and 2.4 m, respectively; water usage is assumed to 1.2 m^3 per day, with a use-weighted transfer efficiency for radon to air of 0.55; the ventilation rate is assumed to be in the range 0.2-0.8 h^{-1}. (References for source contribution estimates: outdoor air (16); U.S. concrete (17); alum-shale concrete (18); water (19); soil flux (20).) 37 Bq m^{-3} equals 1 pCi l^{-1}.

0.7 pCi l^{-1} h^{-1} (based on ref. 20), corresponds well with the indoor observations. However, houses have understructures that might be expected to impede substantially the ingress of radon, at least by diffusion. In fact, as discussed in more detail in a recent review of the source of radon indoors (19), although

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transport via diffusion accounts well for observed fluxes from building materials and exposed soil, and could account for comparably small fluxes from the soil through some understructure materials (such as concrete), diffusion cannot account for the total entry rates observed specifically in single-family houses. Another mechanism must account for the efficiency with which radon from soil enters homes. It appears that this mechanism is bulk flow of soil gas driven by small pressure differences between the lower part of the house interior and the outdoors.

As it turns out, such pressure differences are precisely the cause of ventilation in homes during seasons when the windows are closed. These pressure differences arise from two environmental factors. First, the difference in temperature between indoors and outdoors causes small pressures across the building shell, with pressures at the bottom pointing toward the higher temperature (e.g., the heated interior) and pressures at the top causing air flow toward the colder temperature. This "stack" effect causes a convection pattern that exchanges indoor air with outdoor, with outdoor air being drawn from the vicinity of the understructure during the heating season. The second factor of importance is wind, which causes a depressurization of the house interior, as well as strong differences in pressure across the different walls that depend on the wind direction. The pressure differences caused by temperature differences and winds are roughly comparable in size, averaging on the order of a few pasqual (with higher values in relatively severe climates). These extremely small pressure differences account for air infiltration through walls (and other components of the house), the dominant contributor to home ventilation during heating season. These same pressure differences can, in principle, drive the small flows of soil gas that can account for the observed rate of radon entry into homes: soil gas contains enough radon that only 0.1% of infiltrating air would have to be drawn from the soil (19). Before proceeding to the studies specifically addressing this possibility, I note that it is often very useful to parameterize infiltration rates in terms of the temperatures differences and winds that drive them, and a very simple and useful model for doing so is now in wide use (21).

Recent work has begun to characterize directly the potential for pressure differences to cause entry of radon via soil gas, probably through imperfections and penetrations in the house understructure that permit passage of the relatively small amount of soil gas required. A study of radon entry in a single-family house with a basement analyzed the entry rate versus the ventilation rate, measured over a period of months, and concluded that entry could usefully be represented by a sum of two components: one - the smaller - independent of ventilation rate, much as diffusion would be, and a larger term that is proportional to ventilation rate, as pressure-driven flow might be (13). Moreover, the authors concluded that the observed pressure and soil parameters were consistent with the soil-gas flow rate that was

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implied by the measured concentrations and ventilation rates. More detailed theoretical work (22) is helping to formulate a fundamental picture of the pressure and velocity fields in the soil surrounding homes with basements. Finally, recent experiments have directly observed, in two houses with basements, the underground depressurization implied by this picture, and have measured underground soil-gas movement by injecting and monitoring tracers (23). It is interesting to note that these results may also have significant implications for entry of other pollutants from the soil.

In respect to other housing types, the basement studies have given results that might also be expected to apply in large part to slab-on-grade structures, where the pressure difference generated can still draw soil gas through any penetrations in or around the slab. However, direct measurements in such structures have not been performed. The other understructure type of substantial importance is the crawl-space, which to some extent isolates the interior from the soil - at least in respect to pressure-driven flow between the two. Limited measurements of the transport efficiency of radon through crawl-spaces yield the result that a substantial portion of the radon leaving uncovered soil manages to enter the interior, even if vents are open to permit natural ventilation of the space (12).

In retrospect, this is not entirely surprising, since the stack effect will still tend to draw infiltrating air into the home from the crawl-space, which can retain radon from the soil in conditions where winds are not sufficient to flush it to the outdoors via the vents. Furthermore, for structures where the vents are sealed shut, e.g., to save energy, it is conceivable that the crawl-space still provides sufficient connection between the house interior and the soil that pressure-driven flow can enhance the flux from the soil above levels associated merely with diffusion; the work reported in ref. (12) may have observed this effect. Another result of this study is that energy conservation efforts that focus on tightening the floor above a crawl-space can significantly reduce infiltration rates, while reducing radon entry a corresponding amount, as a result of which indoor concentrations are little affected.

Thus sufficient mechanisms exist to account for the substantial amount of radon that appears to enter homes from the soil, apparently without great regard to understructure type. However, this does not imply that other sources of radon are unimportant. It is clear that materials utilized in a building structure <u>can</u> contribute substantial indoor concentrations, although this is not usually the case (even for natural stone that is higher than average in radium content). Moreover, in buildings that are relatively isolated from the ground, such as multi-story apartment buildings, indoor concentrations are expected to be lower than average - as is often the case in central European dwellings -

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and to arise primarily from the building materials and, for typical U.S. infiltration rates, from radon in outdoor air.

Water

Probably more important than building materials, as a source of radon in certain parts of the housing stock, is domestic water drawn from underground sources. Surface waters have radon concentrations too small to affect indoor concentration when used indoors, but ground water is in a good position to accumulate radon generated within the earth's crust. As a result, very high radon concentrations can be found in associated water supplies: as an example, concentrations exceeding 100,000 pCi/l (3.7×10^6 Bq/m^3) have been found in wells in Maine (24). With normal water use, if the radon from such (admittedly rare) water enters the air of a typical house, an indoor concentration of about 10 pCi/l would result, among the higher levels observed.

Past examinations of the overall potential contribution from water supplies have been little more sophisticated than the estimate just given, which corresponds to a ratio of radon in air to radon in water of 10^{-4}, comparable to estimates and direct observations made by a number of authors (e.g., ref. 24). However, substantial data have recently become available on concentrations of radon in public water supplies drawn from ground water (25), indicating that the majority of such supplies have concentrations below 1000 pCi/l, but that a very small percentage has concentrations exceeding 100,000 pCi/l. Moreover, data are available to assess the effect of radon release to indoor air in a more comprehensive way: a very recent analysis has combined information on water use rate, efficiency of radon release from domestic water used in various ways, house volumes, and ventilation rates, to yield a frequency distribution of air-to-water ratios that is approximately lognormal and that has an arithmetic mean of about 1.1×10^{-4}, close to the value cited above (26). The importance of these developments is that they permit quantitative assessment of the contribution of public water supplies to indoor radon concentrations. The preliminary result of such assessment is that such supplies contribute an average of approximately 0.03 pCi/l in homes served by ground water, about 3% of the average indoor radon concentrations in U.S. homes (see below). However, the very high water-borne concentrations that are sometimes found will contribute much larger airborne concentrations in the homes affected.

This distribution for the air-to-water ratio may also be used for assessing the contribution from private wells, to the extent that concentrations in water are known. Using data that are available for the approximately 18% of the population using private wells, ref. 26 calculates the indoor radon concentration from water

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for this segment of the housing stock to average about 0.4 pCi/l. Moreover, about 1% of the entire housing stock would be expected to have indoor concentrations from water of about 1 pCi/l, due primarily to concentrations from private wells in high activity areas (such as Maine). The authors emphasize that these estimates for private-well contributions cannot be regarded to be reliable, but it is significant that, if they were approximately correct, the portion of the population using private wells would be experiencing significantly higher radon exposures than average, particularly in high-activity areas.

DISTRIBUTION OF INDOOR CONCENTRATIONS

Despite a broad range of efforts to characterize indoor radon, and a significant number of studies that have included measurements in existing U.S. homes, no unequivocal estimates may be made of the concentrations to which the U.S. population is exposed. The reason for this difficulty is that the studies that have been performed have varied significantly in incentives, scientific objectives, selection of homes, and measurement procedures. The results, not surprisingly, vary significantly, as may the conclusions that can be drawn from them. Thus, although the community has a general appreciation that the average indoor concentrations is in the vicinity of 1 pCi/l and that a notable number of homes exceed 10 pCi/l, no useful quantitative appreciation of the actual distribution in U.S. homes has been available. Knowledge of this distribution is essential in formulating a strategy for controlling excessive concentrations, as well as for making a reliable estimate of even the average population risk.

An obvious solution to this difficulty is to carry out measurements in a valid statistical sampling of U.S. homes. Given our current appreciation of typical concentrations and the incidence of high levels, it is thought that monitoring of perhaps 1000 to 2000 homes would determine mean concentrations very accurately and ascertain the fraction of homes at high concentrations (e.g., 10 times the mean) to a reasonable accuracy. However, although the Federal agencies interested in indoor air quality have been seriously considering the potential for a national survey of radon and other pollutants, this will not occur very rapidly, if at all. The main effect of the Federal evaluation may be to formulate a design that enhances the potential for aggregating results from smaller regional efforts.

Regardless of such efforts, the data already available are quite substantial and deserve careful evaluation, if only as a basis for proper design of subsequent monitoring efforts. In particular, although past studies have not been conducted with a consistent approach, the number of such studies is substantial, yielding some tens of data sets (with the precise number depending

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on criteria for consideration). For this reason, a systematic analysis of U.S. results has recently been undertaken, explicitly considering the differences between studies and using lognormal representations as a basis for aggregating the various data sets to yield a nominal distribution for the United States. The results are quite robust, i.e., they have little dependence on selection of data sets, on normalizations having to do with season of measurements, and on weighting of the data (27). Figure 3 shows the result of direct aggregation of 19 of the data sets that are available as individual data, totalling 552 houses. Because of the lack of proper normalization and weighting, no general conclusion may be drawn from this specific aggregation, aside from the substantial conformance to a lognormal representation, a result that has been observed in many individual studies.

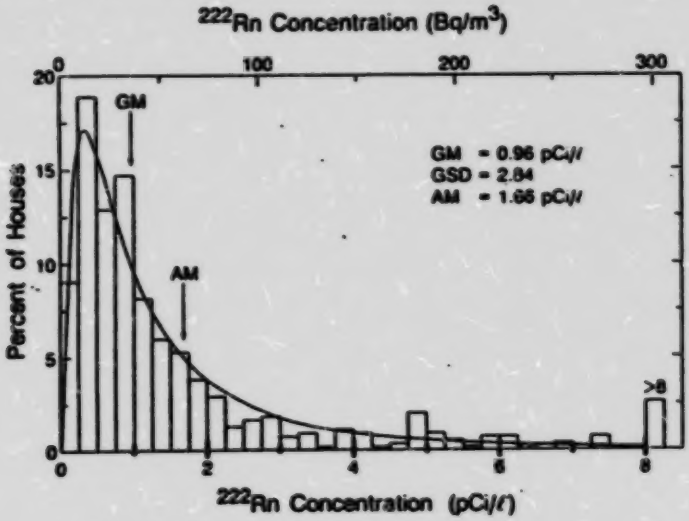

Figure 3. Probability Distribution from Direct Aggregation of the 552 Individual Data in 19 Sets.

The smooth curve is the lognormal functional form corresponding to the indicated parameters, calculated directly from the data.

To lay the basis for citing a principal result, I note that the analysis of ref. 27 utilized from 22 to 38 sets, corresponding to different areas (usually a state or urban area) of the country, with the larger number including monitoring efforts that were

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prompted by some prior knowledge of a potential for elevated concentrations. Characterizing the results of each set in terms of a lognormal function, the geometric mean radon concentrations from these sets range from 0.3 to 5.7 pCi/l (11 - 210 Bq/m^3), with geometric standard deviations ranging from 1.3 to 4. As just noted, the results of aggregating these sets are quite robust, the main differentiation among different aggregations being that including the full 38 sets yields somewhat higher results than including only the 22 "unbiased" samples. The overall result, relying primarily on the 22-set aggregations and including a renormalization of data taken only during heating season, is a geometric mean of about 0.9 pCi/l and a geometric standard deviation of 2.8, implying an average concentration of 1.5 pCi/l and 1 to 3% of houses exceeding 8 pCi/l. This result can only be associated with the portion of the housing stock consisting of single-family houses, since 99% of the data are drawn from such houses. However, this is the dominant element in the housing stock, and the results of this analysis suggest that of the order of a million houses have annual-average concentrations averaging 8 pCi/l or more. This corresponds to exposures approaching the 2 WLM/yr remedial-action limit recently recommended by the National Council on Radiation Protection and Measurements (NCRP) (28). Another interesting observation from this analysis is that the geometric means of the 22 sets are themselves lognormally distributed, with a geometric standard deviation of 2.0. This index demonstrates the substantial variability in mean radon concentration from one area to another and indicates the potential value of strategies that locate homes with high concentrations by first trying to identify areas that have unusually high mean concentrations.

We are still faced with difficulty in estimating concentrations in apartments (and, of course, in other types of buildings). Indications are, based on a few measurements (such as a single third-floor apartment in ref. 3), that concentrations are typically a few tenths of a pCi/l, substantially lower than concentrations in single-family houses. In fact, for an apartment or other building where the average space is relatively well-isolated from the ground, the major contributions to indoor concentrations may be expected to be outdoor air and building materials. The few measurements made to date in the United States are consistent with this expectation, which is also confirmed by the much larger European efforts monitoring concentrations in apartments.

Overall, the approximate contribution of various sources to U.S. residences may be summarized as in Table 1. There it is seen that the dominant contributor to indoor concentrations in single-family houses is the soil, with water and building materials contributing only a few percent. In contrast, for large buildings, the main contributors appear to be the building material and the outdoor air, which also contributes significantly to concentrations

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in single-family housing. However, for the portion of residences served by private wells in high activity areas, the contribution from water may be much large than in ordinary circumstances.

Table 1.

Approximate Contributions of Various Sources to Observed Average Indoor Radon Concentrations

	Single-Family Houses (pCi/l)	Apartments (pCi/l)
Soil potential (based on flux measurements)	1.5	< 1
Water (public supplies)	0.01*	0.01*
Building materials	0.05	0.1+
Outdoor air	0.2	0.2
Observed indoor concentrations	1.5	(0.3)

* Applies to 80% of population served by such supplies; contribution from water may average about 0.4 pCi/l in homes using private wells, with even higher contributions in high-activity areas.

\+ A higher contribution to apartment air is suggested on the presumption that, on the average, apartments have a higher amount of radon-bearing building materials per unit volume than do single-family houses.

BEHAVIOR OF RADON DAUGHTERS INDOORS

Basic Considerations

Even for a given indoor concentration of radon, the concentrations of its daughters (or "progeny") and their physical state can vary substantially. The behavior of the daughters is determined by their fundamental physical and chemical characteristics. Their chemical activity is what distinguishes the

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daughters substantially from radon itself: the daughters are chemically active and can therefore attach to airborne particles, to indoor (macroscopic) surfaces, and - indeed - to the human tracheobronchial tract, where they can deposit either directly or after attachment to airborne particles. On the other hand, the detailed behavior and health significance of the daughters is influenced greatly by their half lives and decay modes, indicated in Figure 4. The two alpha decays that impart the radiation dose of greatest significance are shaded in the figure and are both the results of decay of polonium isotopes. The amount of (polonium) alpha energy that will ultimately be emitted from an arbitrary mixture of radon daughters in air is uniquely specified by the concentrations of the first three daughters, ^{218}Po, ^{214}Pb, and ^{214}Bi (known as Radium A, B, and C in earlier years). The next daughter, ^{214}Pb, has such a short half life that its activity concentration is, for practical purposes, identical to that of its parent, ^{214}Bi. Finally, ^{210}Pb has such a long half life that it is effectively cleared from indoor air - as well as from the lung - in contrast to the earlier daughters, whose 3, 27, and 20 minute half lives permit their accumulation in buildings with typical ventilation rates and their decay in the lung before they are cleared.

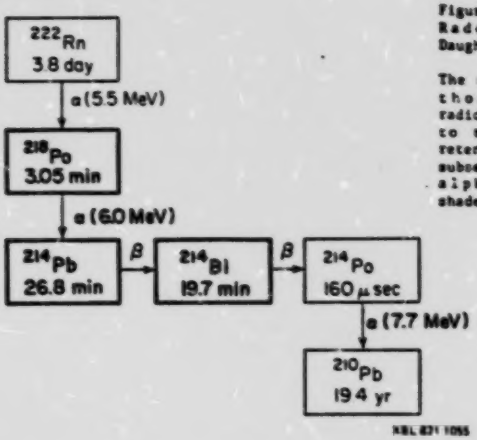

Figure 4. Decay Chain of Radon 222 and its Daughters.

The shaded isotopes are those of primary radiological interest due to the potential for retention in the lung and subsequent irradiation by alpha decays (also shaded).

A useful measure of daughter concentration, the potential alpha energy concentration (PAEC), is therefore determined from the individual daughter concentrations by the expression, PAEC = $K(0.10xI_1 + 0.52xI_2 + 0.38xI_3)$, where I_i is the activity

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concentration of the ith daughter and the constant K has a value that yields a PAEC of approximately 1 WL (working level) - equal to 1.3×10^5 MeV/l - when all of the daughter concentrations are equal to 100 pCi/l. Alternatively, one can measure the concentration in terms of an equilibrium equivalent daughter concentration (EEDC), which is the concentration that - if attributed to every daughter - yields the same PAEC as the mixture that is actually present. In fact, equilibrium - a condition where all the daughters have the same concentration as radon - would only be attained if daughters were only removed by radioactive decay. It is useful, therefore, to define an equilibrium factor equal to the ratio of EEDC to radon concentration. In the real world, daughters are removed from the indoor air by several mechanisms, so that the equilibrium factor is always less than 1, most frequently in the range 0.3 to 0.7.

Were it not for the chemical activity of the daughters, the departure from equilibrium would depend solely on the ventilation rate. But the fact that the daughters can attach to particles or to surfaces, and that these attachment rates can vary with conditions, makes general characterization of the state of the daughters - and of its dependence on ventilation rate, particle concentrations, and other factors - exceedingly complex. However, since we are dealing only with a few species, whose rate of production from early members of the decay chain is determined solely by known half lives, it is possible to specify a relatively straightforward framework for considering the behavior of the daughters.

Figure 5 illustrates, for an unspecified daughter, various of the mechanisms for changing the state (or presence) of the daughter, other than radioactive decay itself. Because the deposition rates for the daughters depend strongly on whether or not they are attached to particles - and indeed on the particle characteristics - airborne particles play a crucial role in determining the concentrations that are present in the air, and potentially on the radiation dose that results from a given concentration. Given the parameters that are indicated in Figure 5, one can write down a system of mass-balance equations, following Jacobi (29), that determine the concentrations, based on given rate constants, or - conversely - that can determine specific rate constants on the basis of experiments that measure individual daughter concentrations. Practical application of such a theoretical approach usually requires assumptions that simplify the picture. One of the usual simplifications is consideration only of a single well-mixed space. Another is the lack of differentiation of rate constants on the basis of particle size or chemical composition.

These simplifications aside, key issues of interest are the rate of attachment of radon daughters to particles, as well as the rate at which free and attached daughters deposit on walls. (In many cases, deposition is parameterized in terms of the "deposition

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velocity", which - for a given space - is proportional to the deposition rate.) By way of perspective, in contrast to typical ventilation rates on the order of 1 h^{-1} and daughter radioactive decay constants that are similar (or, in the case of ^{218}Po, one order of magnitude higher), rates of attachment to particles, for typical particle concentrations, appear to be on the order of 50 h^{-1}, with slightly lower rates - perhaps 15 h^{-1} - for plateout of unattached daughters onto interior surfaces. In contrast, rates for deposition onto walls of airborne particles (and of any daughters attached to them) are very low, on the order of 0.1 h^{-1}. As a result, an atmosphere with low particle concentrations tends to have a higher overall rate of deposition onto the walls - because a higher proportion of the daughters are unattached - and a lower equilibrium factor. This condition can, of course, be attained by use of particle-cleaning devices. However, the advantage indicated by the lower equilibrium factors (and hence lower PAEC) may be balanced by the fact that the detailed behavior of unattached daughters in the lung may cause a more significant radiation dose than that associated with attached daughters.

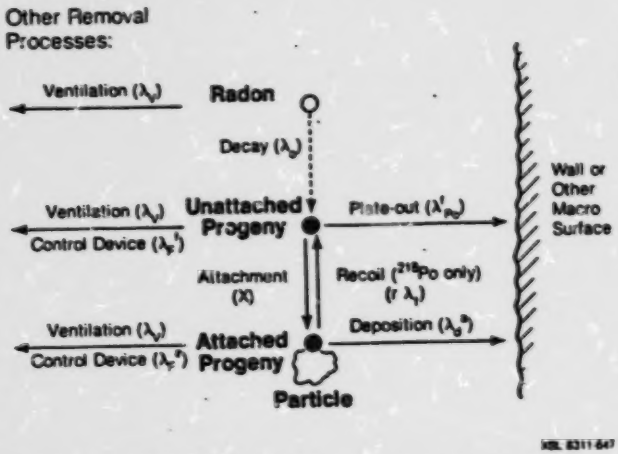

Figure 5. Daughter Removal Mechanisms (Other Than Radioactive Decay) and Associated Rate Constants.

Once created by decay of its parent, a daughter may attach to airborne particles, a process that is usually considered to be reversible for ^{218}Po because of the substantial recoil energy associated with alpha decay. Whether attached or not, a daughter can be removed from the indoor air by plateout/deposition on indoor surfaces, by ventilation, or by processing of the air through an air-cleaning system.

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Recent Results

The complexity and importance of radon daughter behavior, as well as the potential interest in air-cleaning as a control technique, has given rise to a substantial amount of work - both experimental and theoretical - on characterization of radon daughters. A great deal of such work is reported in papers in references (1) and (2), as well as in other publications. References 30 - 32 constitute effective reviews. Here it is worth mentioning a few examples of important progress over the last several years.

Experiments in small and room-sized chambers, and related analysis in terms of the Jacobi model, have suggested the values for deposition rates indicated above (33). This and other work has demonstrated that the rate at which "unattached" daughters plate out, while very high as compared with particle deposition rates, is smaller than would occur if the daughters were present in the form of single unattached atoms (which would have a very high diffusion constant). The implication that an unattached daughter is actually a cluster of atoms including a daughter atom appears to be confirmed in experiments that measure the size distribution of daughters: the daughters appear to divide into two regimes, one mode having a size median diameter of about 100 nm, as might be expected based on the size distribution of particles typically present in the room, and a smaller fraction with median diameter in the vicinity of 10 nm, perhaps an order of magnitude greater than the size expected of a single ^{218}Po atom (34).

Considering what is known about the behavior of radon daughters, estimates have also been made of the effect of air cleaning techniques on the radiation dose to the lung. Such estimates suggest that the radical reduction in PAEC that is possible by air cleaning may not cause a corresponding decrease in estimated health effects; it is even possible that there is no decrease at all (35). On the other hand, a detailed review of dosimetric models yields the result that, although the PAEC is an imperfect measure of dose and - ultimately - of health effects, it is still a reasonably good indicator, assuming that parameters are in the normal range (36). These results would seem to suggest that - to the extent that air-cleaning devices result in particle concentrations outside the normal range - there is the potential that PAEC is no longer a good indicator of dose. On a related matter, the effectiveness of generally available particle-cleaning devices is highly variable, as indicated in Figure 6, from ref. 32, where it is found that - although systems based on HEPA filters and electrostatic precipitation can have a substantial particle cleaning rate (and an attendant substantial effect on PAEC) - many devices, especially the small and inexpensive ones that have recently become very popular, can have very small removal rates.

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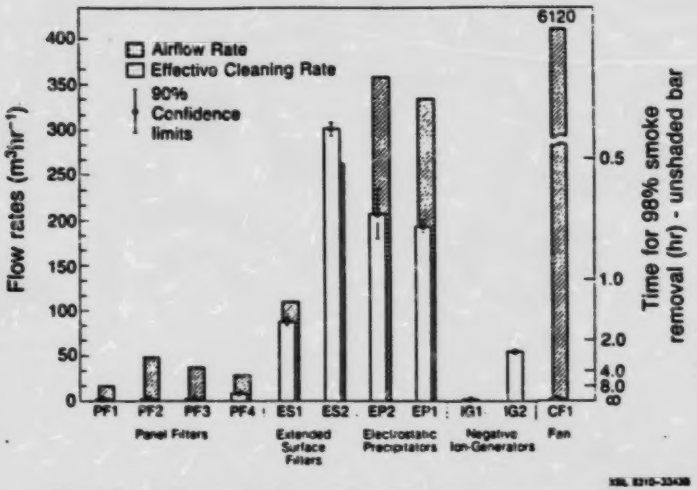

Figure 6. Performance of Various Unducted Air-Cleaning Devices for Removal of Airborne Particulates (generated in these experiments by a cigarette-smoking machine).

Bars give flow rates: shaded is measured air flow rate, unshaded is effective rate at which air is cleaned of particles, calculated as the inflow of particle-free air required to produce the observed decay rate of cigarette smoke. (The right-hand vertical scale indicates 98% clearance times for each device.)

Finally, Figure 5 does not explicitly indicate one of the potentially substantial influences on daughter behavior, i.e., the fact that air within a room moves and that the pattern and rate of air movement can significantly affect plateout rates. Recent advances have made it possible to simulate air movement in an enclosure, thereby removing the simplifying assumption ordinarily used for simulation of radon-daughter behavior, that of a well-mixed room. The more detailed formulation permits treatment of the boundary layer more realistically, thereby providing a basis for determining the manner in which the plateout rate (or deposition velocity) depends on conditions in the room and, particularly, near the wall (37).

The importance, not only of ventilation rate, but also of other measures of air movement, indicates the need for a more complete understanding of the manner in which buildings operate if we are to understand how radon daughters behave. A similar conclusion arises from considering the manner in which radon enters

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buildings, where it has become clear that the building is not a passive object into which radon diffuses, but actively contributes to the entry of radon indoors. And, indeed, both of these issues - i.e., radon entry and daughter behavior - are linked to the question of ventilation rate in a much more subtle way than was initially envisioned. Whereas the ventilation rate might be thought to influence indoor concentrations primarily in providing a means for removal of radon from the building interior, it is now clear that the same factors that account for infiltration affect radon entry decisively and - indeed - comparable factors drive air movement indoors, which has its influence on the behavior of the radon daughters. In a similar way, consideration of how to control excessive indoor concentrations requires attention to the several factors that determine indoor concentrations and that therefore offer the potential for reducing those that are deemed excessive.

STRATEGIES FOR CONTROLLING INDOOR CONCENTRATIONS

There is ample evidence that indoor radon concentrations constitute a significant portion of natural radiation exposures. As determined either by direct measurement of the radon daughters or by measurement of radon and assumption of typical equilibrium factors, even average concentrations yield estimated lung cancer rates that equal a substantial portion of the lung cancers that are not associated with cigarette smoking. Thus the average radon concentration in U.S. dwellings appears to account for thousands of cases of lung cancer annually. And, considering the apparent distribution of indoor concentrations, a substantial number of homes have very high concentrations. As noted above, perhaps a million U.S. homes have concentrations causing exposures that exceed the remedial action criterion recently recommended by the NCRP; occupants of these million homes have exposures comparable to those now received by uranium miners. Faced with a large number of homes apparently in need of help, we must consider how effectively to find these homes and to reduce concentrations significantly. A related question is how to lower the average exposure of the population, if this seems desirable.

Control strategies entail two basic elements: 1) the specific techniques for controlling concentrations, and 2) the framework within which such techniques are applied to homes found to be in need of action. The control techniques available correspond quite closely to the factors found to affect indoor concentrations. For several of the major classes of indoor pollution - whether radon, combustion products, or airborne chemicals - these factors may include the source strengths for the pollutants of interest, the ventilation rate (and ventilation effectiveness), and reactions of the pollutants with each other and with the buildings or its contents. For each pollutant class, concentrations appear to be distributed approximately lognormally,

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and the largest contributor to the width of the distribution is typically the source strength, but - in each case - variability in ventilation rates and in reaction rates contribute significantly. Thus, the apparent ranking indicated above for the influence of these factors on radon concentrations is not anomalous.

Given our current understanding of the strong variability in radon entry rates and its origin, one technique for controlling indoor concentrations is to minimize entry rates, particularly in cases where they are unusually large. Considering the importance of pressure-driven flow of soil gas into houses through their understructures, substantial attention has been given in recent years to the potential for reducing this flow. It is clear that use of better barriers, sealants, and construction techniques can have a significant effect on the radon entry rate, but this potential appears - in most cases - to be limited, one reason being that slight movements of the house understructure can create small imperfections that appear to be adequate pathways for the entry of soil gas.

An alternative approach that has the potential for reduction of entry rates by large factors is to apply some technique that flushes radon from the region immedistely below the house understructure, effectively presenting an alternative pathway for the radon flux from the ground. In certain cases, where the main entry route is highly localized, as through a drain tile and sump system, provision of local venting is highly effective. In the more general case of a basement or slab-on-grade, one or a few pipes that use a small fan to depressurize the soil (preferably gravel) immediately below the concrete floor can strongly reduce the radon entry rate, in effect by reversing the pressure differential that would ordinarily draw soil gas into the home. In the case of crawl spaces, active ventilation of the space below the house can easily be accomplished, although - as noted above - careful sealing of the floor may be quite practical in this case.

For situations where large entry rates are responsible for excessive concentrations, such entry reduction techniques appear to have the greatest potential effect. However, there are also circumstances where increases in ventilation rates are appropriate, whether because the ventilation rate in question is unusually low, because source reduction techniques do not appear effective for the case at hand, or because - in rare cases of extremely high concentrations - an immediate, if only temporary, solution is required. The primary limitation of increased ventilation rates, especially in homes that have very high concentrations, is that reduction of indoor concentrations by large factors will require increases in ventilation rate by large factors, which is often impractical, uncomfortable, or too expensive, at least for the long term. For homes where only modest reductions are sought, ventilation increases are quite practical, including systems that recover energy that would otherwise be lost - either by

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incorporation of an air-to-air heat exchanger between incoming and outgoing air streams or by recovery of heat from an exhaust ventilation system. (However, an exhaust ventilation system must be used with some caution, since it may result in an increased depressurization of the house that leads to higher radon entry rates.)

An alternative means of control is, of course, use of air cleaning systems to remove radon daughters. The most common of these, as suggested above, employ particle removal techniques such as filtration and electrostatic precipitation. However, although such techniques can substantially reduce the daughter concentrations as measured by the potential alpha energy concentration, their effect on the actual dose to the lung is far from clear. As a result, the radon research community as a whole presently favors employment of source-reduction techniques as the first choice and use of increased ventilation rates as the next option.

The other element in a control strategy, formulation of a framework within which concentrations are controlled, is - if anything - more difficult to define. Even given an adequate understanding of the general occurrence of radon in homes (and other buildings) and of the attendant health implications, such a framework itself involves several interconnected elements. One is some agreement on objectives of the control strategy, including specification of concentration limits or guidelines. A related issue is allocation of responsibility, both for locating houses with excessive concentrations and for implementing the appropriate control techniques. Next is formulation and implementation of the actual scheme for identifying areas and individual houses with high concentrations. And finally is the logical structure that indicates what control approach should be used in each situation.

Formulating this framework will be no easy task. Parts of it are already being attacked, often helter skelter, but it is important to appreciate that no satisfactory and systematic treatment of the problem of indoor radon will be possible without conscious attention to each of these elements and to their interconnections. Some of the elements, e.g., the formulation of a scheme for finding cases in need of help, depend largely on our growing understanding of the factors that affect concentrations - a primarily scientific question. But other elements, such as that of responsibility, have very substantial social and even political components. As a result, attacking the problem of indoor radon goes far beyond the purely scientific or technical.

CONCLUSIONS

Due to work of recent years, the research community has made

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substantial progress in understanding the factors that affect indoor concentrations of radon 222 and its daughters. A very wide range of concentrations is present in homes, e.g., in the United States, and these are found to depend, as expected, on source strengths, ventilation rates, and daughter reactions. The highest variability is found in source strengths, which - for single-family homes - are contributed primarily by radon from the soil, but with substantial contributions in some cases from water and building materials. Ventilation rates also affect indoor concentrations directly, although they do not appear to vary as much from house to house as do entry rates. Perhaps the more interesting aspect of ventilation rates is their indirect influence on source strengths and daughter removal because of common factors - such as temperatures and pressures - that affect source strengths, ventilation rates, and daughter behavior. As to the behavior of daughters themselves, considerable effort is being devoted to an understanding of the rates at which they attach to particles or to interior surfaces and to the behavior of "unattached" versus attached daughters.

Corresponding to the relative influence of these factors on indoor concentrations, we have available to us an array of techniques for controlling excessive concentrations, including reduction of the source strength, provision of more ventilation (including use of energy-efficient techniques), and removal of the daughters using systems that clear particles from the air. It appears that source reduction, followed by increased ventilation, has the greatest potential effectiveness. But even more challenging than the development of specific control techniques may be the formulation of an overall strategy within which they may effectively be employed.

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Mr. SCHEUER. Thank you very, very much, Dr. Nero.

Congressman Ritter of Pennsylvania.

Mr. RITTER. Thank you, Mr. Chairman, and I will say publicly what I was attempting to say privately, and I am sorry, because I think Dr. Nero's conclusions were extremely important to precisely what I was saying.

I have been interested in the subject of risk assessment and trying to put hazards in perspective, and I think this panel has done a pretty excellent job in focusing on the subject on putting hazards in perspective in the area of radon.

I would like to say that Dr. Cohen also has a radon test kit. I guess we mentioned the Track-Etch competition, and we should just say that Dr. Cohen has done a great service to people in my district, providing them with $10 carbon absorption, little cans with activated carbon in there and an absorption shield, and I am very grateful for that, and so are my constituents.

Frankly, gentlemen, I think your testimony speaks for itself. I do not have any questions.

As I said, I think the testimony speaks for itself, and I do not have any questions.

Mr. SCHEUER. Excuse me, Don.

Mr. RITTER. I am sorry. The testimony, I thought, spoke for itself, and I do not have any questions.

Mr. SCHEUER. This testimony was extremely interesting.

Dr. Nero, you did talk about exposure to cancer-producing radiation of 1,000 to 10,000 times something. That sounds like a tremendously increased order of magnitude of risk for getting cancer.

Now, it is true that people should not panic, but shouldn't that be a matter of deep concern to people?

Dr. NERO. I certainly think it should be, and also to the people's Government.

Mr. SCHEUER. Pardon?

Dr. NERO. I think it should be a deep matter of concern to the people and to the people's Government.

Mr. SCHEUER. Yes, but the people are a lot more concerned than the people's Government, at least as far as the executive branch is concerned. It is remarkable to me that there is so much more concern in the Congress on a completely bipartisan basis—and again, I want to pay tribute to my Republican colleagues. They are really tuned in on this problem. They are relating to their constituents' concerns very, very sensitively, and it is remarkable to me that the Congress, on a totally bipartisan basis, is so far ahead of the administration in their awareness of how deeply people feel about this and how clear the scientific evidence is that there is a risk to be coped with, a very real risk. Do you disagree with that?

Dr. NERO. I can only agree with you.

Mr. SCHEUER. Let me ask you, Dr. Nero, what has happened to research funding at DOE and EPA over the last 10 years on the radon issue?

Dr. NERO. Well, that is a complicated question.

Mr. SCHEUER. Well, let's have a real simple answer.

Dr. NERO. Different things have happened at DOE and at EPA. Basically, as I see it—and I am only one member of the research community—the research funded by the Department of Energy has

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maintained itself at a relatively constant level over a long period of time, decreasing somewhat if you consider—in fact, quite significantly if you consider the small changes that have occurred and inflation and so forth.

The EPA's activities have jumped around very substantially. In the late 1970's, the Environmental Protection Agency, particularly the Office of Radiation Programs, undertook substantial efforts in the area of indoor radon. In fact, the EPA was getting, as you know, into indoor air quality in general in a large way.

But, beginning in 1980, those programs were cut back very substantially. In fact, last year I remember a member of the staff at EPA telling me that ORP had a budget of zero persons and zero dollars for indoor radon. This was about a year ago.

Now, obviously, things have changed, and I can only say that they have changed for the better. I just hope that the funding both at EPA and the Department of Energy and at other places that have a substantive concern in this area increases to a level that is somewhat closer to—more appropriate to the problem that we have facing us.

Mr. SCHEUER. Congressman Ritter.

Mr. RITTER. Thanks, Mr. Chairman.

I would just like to ask whether this radon case study says anything about the Nation's ability to set priorities, put hazards in perspective, and go to work on the most dangerous ones first. Do you want to start off, Dr. Wilson?

Dr. WILSON. I certainly think it does. I have been a strong pusher for putting hazards in perspective, and also not necessarily dealing with all of them equally. But, nonetheless, if two hazards look very different, it makes it very clear to a risk manager or someone who is deciding about risk that he is deciding to ignore large risks and to start regulating a small one.

Now, I know there is a lot of objection to this. Particularly, I and Don Ritter have been strongly attacked by the environmental community, saying all you can do with risk assessment is prioritize risks. I really could not agree very much more with that statement.

However, the environmental community who make those objections do not prioritize risks. They do not even prioritize the limited sort of radiation risks they are talking about, and they do not prioritize the carcinogenic risks. They calculated one little individual risk and said: This is dangerous; attack that one and beat it down to the earth and thereby ignore and thereby not put any comparison with the other ones. They fail to do the very prioritization they should be able to do.

Mr. RITTER. Do you think if we had such a capability at the Federal level that we might have gotten wind of this radon problem a lot sooner?

Dr. WILSON. I think that is probably true. I think even one of the better agencies doing risk assessments—the EPA—it is quite clear that what they do in the risk assessment business is very much limited by that perception of the political realities and the constraints on which they are based.

So I think it is very important that whatever comparison of risks try to be removed as far as possible from the political realities of an individual agency, and in fact there is one proposal up before—

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there were hearings in this House only yesterday on a bill to ask NIOSH to have risk assessment reviews of some of its own programs, and that is exactly wrong, of course, because you don't want one agency reviewing its own programs and saying, "Well, what we have done is marvelous," and just rubberstamping what the staff has done. It has got to be reviewed by another group from outside that agency, and if it is good, it will stand up.

Dr. COHEN. Could I reply to your question in a very clear way, I think. One Government agency that is quite rational about these matters is the Department of Transportation, and they are willing to spend about $300,000 per life saved.

We have just heard that in radon areas we are not willing to spend a few thousand dollars per life saved, whereas in anything involving the nuclear industry, which is radiation, the same type of radiation—in reactor accident prevention, we are spending $2 billion per life saved. In radioactive wastes, we are spending several hundred million dollars per life saved, and so on. So that is, I think, the answer to your question.

Mr. RITTER. Dr. Nero, you had some cogent statements on that subject during your testimony. Do you wish to add anything?

Dr. NERO. I think the comments that the other people have made speak for themselves. I must say that one of the most compelling things for me is this comparison between the uranium mill tailings exposures and the question of indoor radon, where you are not talking about different classes of exposures; you are not even talking about different kinds of radiation. You are talking about the same stuff.

There is a real problem in prioritizing the expenditures of the Federal Government in research or other activities in terms of environmental exposures.

Mr. RITTER. Mr. Chairman, I yield back. I have not even taken my 5 minutes.

Mr. SCHEUER. Well, I want to thank you all. It is almost 6 o'clock, and you have been here since 2, and you have gone way above and beyond the call of duty in your patience and your understanding and your good humor and in the excellence of your testimony. We all appreciate it very, very much.

Now, I do have a number of questions that I want to ask, but, mercifully, we are going to ask them by mail. So I again would ask unanimous consent for the record to be held open for about 12 days so that I and other members——

Mr. RITTER. No objection, Mr. Chairman. [Laughter.]

Mr. SCHEUER [continuing]. So that I and other members can ask questions by mail.

I want to thank this panel for their exceptionally fine and persuasive testimony. It has been a real privilege to listen to you.

The session is adjourned.

[Whereupon, at 5:38 p.m., the subcommittee recessed.]

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APPENDIX

Post-Hearing Questions and Answers Relating to the October 10, 1985 Hearing

Submitted by Department of Energy

ADDITIONAL QUESTIONS FOR THE RECORD

Question 1: Three separate offices within DOE conduct indoor radon research. What level of research support has been devoted to each office in FY 1985, FY 1986, and FY 1987?

Answer: The three offices within DOE which conduct radon research are: the Office of Conservation and Renewable Energy's Office of Buildings and Community Systems (CE/OBCS); the Office of Energy Research's Office of Health and Environmental Research (ER/OHER); and the Bonneville Power Administration (BPA). The respective indoor radon budgets for these offices in FY 1985 and FY 1986 are indicated below.

	FY 1985	FY 1986
CE/OBCS	$ 230K	$ 230K
ER/OHER	$1,425K	$1,400K
BPA	$ 250K	$ 250K

FY 1987 budget information will be available when the President's budget is submitted to Congress.

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ADDITIONAL QUESTIONS FOR THE RECORD

Question 2: Are the DOE research needs for radon related to the research needs for other indoor air pollutants?

Answer: DOE research needs for radon are related to the research needs for other indoor air pollutants. For example, CE/OBCS conducts research to quantify any increases in levels of indoor radon and radon progeny which may result from energy conservation measures that increase the air-tightness of residential and commercial buildings. In this research, radon is one of a group of indoor pollutants that may present health risks. Other pollutants are volatile organic compounds, formaldehyde, combustion products, and allergens and pathogens. Research devoted to characterizing pollutant sources and the factors which influence indoor levels, air movement, measurement techniques, and mitigation strategies is essentially the same for radon as for the other pollutants.

Similarly, BPA performs research on radon and other indoor pollutants in support of BPA's efforts to deliver conservation services to homeowners and renters in the Pacific Northwest in a safe and healthful manner. BPA's applied research and field assessments of radon levels are important components of the BPA home weatherization program.

ER/OHER research on radon is devoted to estimating health risks from exposure to environmental radon. Since the health effects associated with a pollutant are unique to that pollutant, ER/OHER research needs on radon are not directly related to research needs for other pollutants.

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ADDITIONAL QUESTIONS FOR THE RECORD

Question 3: Would research on other common indoor air pollutants be more costly if it were conducted separately from indoor radon research? Are there any special or unique characteristics of other indoor air pollutants that indicate that research on such pollutants should be conducted separately?

Answer: All three of the DUE offices which conduct radon research do so within larger research efforts which also address other pollutants found indoors. For example, CE/OBCS conducts indoor radon research as part of its infiltration, ventilation, and indoor air quality research program. DUE believes that this is the most cost-effective way to conduct its indoor radon research. Research on other indoor pollutants, however, would not be significantly more costly if it were conducted separately from indoor radon research.

However, there are unique characteristics for each indoor air pollutant, including radon, which indicate that certain aspects of research can be conducted separately. For example, radon is the only indoor air pollutant which has its source outside of the indoor environment. Therefore, research to determine source concentrations, soil properties, and building characteristics which contribute to high indoor radon levels can be conducted independently from other indoor pollutant research.

Because each indoor pollutant has its own sources, and possibly unique health effects, health effects research must be conducted for each on a pollutant-specific basis.

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ADDITIONAL QUESTIONS FOR THE RECORD

Question 4: Please describe the manner in which DOE coordinates its radon research with EPA. Are specific research projects jointly planned? Has EPA been given an opportunity to comment on proposed DOE radon projects?

Answer: DOE coordinates its research on radon with EPA in many ways. For example, DOE and EPA cochair the Interagency Committee on Indoor Air Quality (CIAQ) Radon Workgroup which coordinates Federal current and planned radon research, and provides EPA the opportunity to comment on proposed DOE radon research projects. In addition, both DOE and EPA serve on the Science Panel and Radon Subpanel of the Committee for Interagency Radiation Research and Policy Coordination which reports to the Office of Science and Technology Policy.

DOE and EPA regularly discuss current and planned radon research. Recent examples include both DOE participation in an interagency meeting at which EPA presented its Radon Management Plan, and a EPA briefing for EPA and other DOE offices on its recent radon research results.

In addition, DOE and EPA jointly plan and conduct radon research. The two agencies recently began research devoted to determining the factors influencing soil as a source of indoor radon. This research is developing a framework for geographically assessing radon source potentials.

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ADDITIONAL QUESTIONS FOR THE RECORD

Question 5: Other countries have addressed radon exposure. What results have been produced from this effort, particularly in the area of effective, low-cost mitigation measures?

Answer: Indoor radon levels have been the subject of research in other countries including Canada, Sweden, West Germany, Austria, France, Finland, England, and Italy. A comparison of limited U.S. data with these surveys indicates that the U.S. distribution is similar, or perhaps shifted to somewhat higher levels than in most of these countries.

In addition, two recent case-control studies of lung cancer cases versus decedents from causes other than cancer have been conducted in Sweden in houses with differing levels of radon. The first showed some evidence of increased lung cancer risks being associated with houses characterized as having elevated radon exposure. However, no numerical risk coefficients were developed. The second study made radon daughter measurements in houses, and estimated risk coefficients for residents within the range of the relative risk estimates made for miners.

Canadian and European researchers are also developing and testing effective, low-cost mitigation measures similar to those being evaluated in the United States. For example, in a recent Commission of European Communities (CEC) report on radon, the following mitigation measures were identified for existing dwellings: depressurization of the soil under the basement slab;

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crawl space ventilation; epoxy paint or aluminum foil treatments of building materials; and heat recovery ventilation. The same report recommended the use of building materials with low radon exhalation rates, ventilated crawl spaces with a monolithic slab treated with an air-proofing material, and heat recovery ventilation for new dwellings.

Under a current memorandum of agreement, DOE (OER) and CEC are planning collaborative research devoted to the development of a predictive capability for estimating environmental radon exposures and effects.

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ADDITIONAL QUESTIONS FOR THE RECORD

Question 6: Mr. Millhone testified that a major objective of DOE's radon work is to synthesize its research results into a useful format for the public. Can you describe your future plans in this area?

Answer: DOE will continue to synthesize its indoor radon research results into a form accessible for use by the public and private industry. DOE also intends to disseminate the results of its research activities to State and local governments. Examples of DOE's efforts include the following publications:

"Home Weatherization and Indoor Air Pollutants"

"Energy Efficient New Homes and Indoor Air Pollutants"

"Indoor Air Quality Guide for Designers, Builders, and Users of Energy-Efficient Residences"

"DOE Research on Indoor Radon" (under review)

"EPA/DOE Information Sheet on Radon" (under review)

In addition, DOE, the Electric Power Research Institute, and the Gas Research Institute maintain a Concentrations of Indoor Pollutants data base of indoor air quality field study results, including radon. Finally, DOE encourages the participation of its staff and radon researchers in conferences, symposia, and workshops related to radon.

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[boilerplate committee roster]

U.S. HOUSE OF REPRESENTATIVES

COMMITTEE ON SCIENCE AND TECHNOLOGY

SUITE 2321 RAYBURN HOUSE OFFICE BUILDING
WASHINGTON, DC 20515
(202) 225-6371

[boilerplate committee roster]

December 20, 1985

Honorable Lee Thomas
Administrator
Environmental Protection Agency
401 M Street, S.W.
Washington, D.C.

Dear Mr. Administrator:

As you know, the Subcommittee on Natural Resources, Agriculture Research and Environment, which I chair, held hearings on October 10, 1985 on the risks posed by indoor radon contamination and on research concerning low-cost mitigation techniques.

Dr. Sheldon Myers, Acting Director of the Office of Radiation Programs, and Dr. John Skinner, Director of the Office of Environmental Engineering and Technology, testified before the Subcommittee. As a follow-up to that testimony, I have attached a number of questions to which I would appreciate a written response for the record in three weeks.

Your cooperation in this matter is appreciated.

Sincerely,

JAMES H. SCHEUER
Chairman
Subcommittee on Natural Resources,
Agriculture Research and Environment

ADDITIONAL QUESTIONS FOR THE RECORD
SUBMITTED BY THE ENVIRONMENT PROTECTION AGENCY

1. Dr. Meyers indicated in his testimony that the EPA is considering conducting an evaluation of epidemiology studies and may consider conducting such a study itself. Does this effort duplicate epidemiological research evaluated by and conducted by the Department of Energy (DOE)? If not, in what way would EPA's activities be different? When will we have preliminary results?

2. Would EPA's epidemiological activities duplicate efforts being conducted by the National Cancer Institute? If not, in what way would EPA's epidemiological research be different?

3. Dr. Meyers also indicated in his testimony that EPA is planning research to check "hot spots". Does this work duplicate DOE efforts?

4. Please describe the manner in which EPA coordinates its radon research with DOE. Are specific research projects jointly planned? Has DOE been given an opportunity to comment on proposed EPA radon projects?

5. For fiscal years 1984 through 1986, please provide the following information: the budget requests to the Administrator, from (1) the Office of Air and Radiation Programs, and (2) the Office of Research and Development, for projects specifically related to radon or indoor air quality; the budget request from the Administrator to the Office of Management and Budget (OMB) for such projects in each of the two Offices; the "pass-back" budget from OMB for such programs in each of the two Offices; and the final budget request to Congress for such projects in each of the two Offices.

6. Please provide the Subcommittee with a description and analysis of the existing laws which EPA believes to provide authority for addressing indoor radon exposure.

7. For each of fiscal years 1984 through 1986, please provide the following information, broken down by Office: the number of FTE workyears spent on, and the total funds spent or committed on, (1) health effects of radon exposure, (2) risk assessment or exposure assessment, (3) mitigation research, including demonstration projects, and (4) other radon-related activities.

8. What type of research would be necessary to develop, evaluate and certify a wide range of low-cost radon mitigation techniques that are both effective over time and applicable to a wide range of housing? Please describe how long such research would be expected to take and include an estimate of its cost.

9. What type of research would be necessary to identify those houses across the nation with indoor radon levels above .02 WL? Please describe how long such research would be expected to take and include an estimate of its cost.

10. What is the present status of EPA's proposal to conduct a "national assessment" of indoor radon concentrations? What are the planned elements of the assessment? When can we expect preliminary results?

11. As research continues, it is becoming apparent that high levels of radon are being found all over the nation, even in areas where there is no evidence that there are unusually rich concentrations of uranium in the soil. How does this fact affect the ability to locate houses with elevated levels of radon?

12. What is the present status of a proposal to conduct a five-year, $10 million radon research and mitigation project? What % in population exposure reduction do you expect to achieve? How did the Agency arrive at this figure?

13. Were any funds internally reprogrammed into indoor radon programs in FY 1985 or FY 1986? Are there any pending plans or proposals to reprogram funds into indoor radon programs? From which programs have these funds been reprogrammed?

14. While EPA has achieved major radon concentration reductions in the demonstration projects in Pennsylvania, some of the houses continue to have radon levels close to the .02 working level threshold. Does this suggest that it may be impossible to reduce radon levels below .02 working levels in some houses?

15. What is the basis for EPA's decision to use .02 WL as the level at which mitigation is recommended?

16. Does EPA believe that radon exposure below .02 WL is an acceptable level of risk?

17. Even "normal" levels of indoor radon may be associated with a risk of lung cancer hundreds or thousands of times higher than the 1 x 10-6 risk often used in risk management decisions in the area of toxic chemicals. Is there a reason to treat the risks of radon exposure differently than risks from other radioactive or toxic substances?

18. How many homes in the country have levels of radon associated with a increased lung cancer risk of 1 in 1,000 or greater?

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19. Would research on other common indoor air pollutants be more costly if it was conducted separately from indoor radon research? Are there any special or unique characteristics of other indoor air pollutants that indicate that research on such pollutants should be conducted separately? If so, please describe those characteristics.

20. What has the EPA done to draw on the substantial experience of European countries with respect to indoor radon? Has the EPA evaluated the "radon reservoir" developed in Sweden as a mitigation device? Has the EPA evaluated the survey and assessment data available in Sweden and Great Britain?

21. What has EPA done to examine radon contamination in drinking water?

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

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OFFICE OF
EXTERNAL AFFAIRS

Honorable James H. Scheuer
Chairman
Subcommittee on Natural Resources,
Agriculture Research and Environment
Committee on Science and Technology
House of Representatives
Washington, DC 20515

Dear Mr. Chairman:

Enclosed are our responses to questions contained in your letter dated December 20, 1985 related to Mr. Sheldon Meyers' testimony before the Subcommittee on October 10, 1985 on indoor radon contamination.

I apologize for our tardy response. Our radon program is addressing new problems and needs, and we are concerned that we accurately describe the current direction and resources of this evolving program. For this reason I am unable to include in this letter our responses to questions 5,6,7,8 and 12, but expect to send them to you very shortly.

If I can be of further assistance, please let me know.

Sincerely,

Jennifer Joy Manson
Assistant Administrator
for External Affairs

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ADDITIONAL QUESTIONS FOR THE RECORD
SUBMITTED FOR THE ENVIRONMENTAL PROTECTION AGENCY

Q 1: Dr. Meyers indicated in his testimony that the EPA is considering conducting an evaluation of epidemiology studies and may consider conducting such a study itself. Does this effort duplicate epidemiological research evaluated by and conducted by the Department of Energy (DOE)?

A 1: (first part of question, on existing studies) EPA's Office of Research and Development recently completed an in-house review of past epidemiology studies and also arranged a workshop with Federal, State, and university participants that focused on coordination of ongoing studies. Future workshops are also planned within the next six to nine months. These and other already established means of coordination among the Federal agencies serve to make these epidemiology projects complementary.

EPA's Office of Research and Development (ORD) has conducted a brief in-house review of past epidemiology studies on radon. A summary of that review is provided below.

Review of Existing Epidemiological Studies
Relating Radon Exposure to Lung Cancer

Existing epidemiological evidence provides convincing support for a relationship of radon exposure and lung cancer incidence in miners. The National Institute for Occupational Safety and Health (NIOSH) recently (May 9, 1985) completed an "Evaluation of Epidemiologic Studies Examining the Lung Cancer Mortality of Underground Miners." In fifteen epidemiologic studies, researchers reported excess lung cancer deaths among underground miners who worked in mines where radon decay products were present. Several studies showed a dose-response relationship between exposure to these products and lung cancer mortality. In two recent studies, investigators reported excess lung cancer deaths due to mean cumulative exposures below 100 working level months (WLM).

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A 1: Continued

Richard Hornung, NIOSH, has completed a risk assessment analysis based on the miners' studies; this is currently under review and should be available within the next several months. Robert Roscoe, NIOSH, is updating the mortality and exposure data for the 4100 miners in the Public Health Service Uranium Miners Cohort which represents miners who worked during 1950-1960. A previous cohort analysis of mortality through 1969 is being updated through 1985 and will include data on miners who received lifetime exposures of less than 120 WLM and data on smoking, lung cancer pathology, and other potential occupational exposures. Edling, et al. (1982), correlated increased lung cancer with living on "high radon ground" and Hess, et al. (1983), correlated increased lung cancer with high radon counties in Maine.

These descriptive epidemiological studies are of limited value, but support the need for analytical epidemiological studies. Axelson, et al. (1981), reported four times more lung cancer in "radon-prone" homes on the west coast of Oeland (a Baltic Island) where mean (geometric) radon decay product levels are four times higher than on the east coast. Although this is a case-comparison study in which the study population is small (210 individuals with 30 or more years at same address), exposure data are limited, and smoking is not fully controlled, it suggests that exposure to radon and radon decay products in dwellings may play a role in lung cancer in the general population (e.g., increased lung cancer risk among male and female residents of homes with more than 0.044 WL compared with residents of homes with less than 0.007 WL). Axelson concluded that further studies of this risk are required.

Bean et al. studied radiation in groundwater in relation to cancer as recorded by a state-wide cancer registry in Iowa for years 1969-1971 and 1973-1978. In addition to the usual associations of lung cancer incidence with increasing population density, they noted that in communities of 1,000 to 10,000 population with water supplied by deep wells (>500 ft. or 152 meters) there was a higher incidence than among communities served by shallower wells. Twenty-eight communities served by

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A 1: Continued

shallower wells were studied to determine if the radium 226, determined between 1958 and 1979, was associated with cancer incidence during the period 1969-1978. The towns were ranked into 3 groups, with 0 - 2.0, 2.0 - 4.9, and greater than 5.0 pCi/L. Since the correlation of radium 226 and gross alpha activity was 0.92, we can infer that the ranking also applies to radon 222. Significant excess male lung cancer occurred in the communities with high groundwater radioactivity and nonsignificant excesses were observed for females. From another study data on smoking in such communities were available, and for the high radiation communities the percent of the population who had ever smoked was smaller than the percent for the lower radiation communities. Other variables, such as percent foreign born, did not alter the radiation lung cancer association.

References:

Edling, C., et al., Effects of low-dose radiation - A correlation study, Scand. J. Work. Environ. Health, 8: Suppl. 1: 59-64, 1982.

Hess, C.T., et al., Environmental radon and cancer correlations in Maine. Health Phys., 45: 339-348, 1983.

Axelson, O., et al., Lung cancer and radon in dwellings. Lancet, 2: 995-996, 1981.

Bean, J.A., Isacson, P., Hahne, R.M.A., and Kohler, J., Drinking water and cancer incidence in Iowa. II. Radioactivity in Drinking Water. Am. J. Epid., 116: 924-32, 1982.

A1: (second part of question, on planned studies)
See answer to question 2.

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Q 2: Would EPA's epidemiological activities duplicate efforts being conducted by the National Cancer Institute? If not, in what way would EPA's epidemiological research be different?

A 2: EPA is planning to conduct an epidemiological study on radon. There are five current environmental epidemiologic studies, all of case-comparison design, being conducted in Maine (EPA), Pennsylvania (Department of Energy), New Jersey (collaborative effort between the State and the National Cancer Institute), Sweden, and Canada. These studies are described in greater detail below.

A. Maine: Initiated over a year ago and expected to be completed in 1989, this study is being conducted as a cooperative agreement between HERL/EPA and Maine Medical Center, University of Maine at Orno, and Maine Department of Human Services. Radon exposures in Maine homes originate from radon in groundwater and other sources. This is the only study where water is a significant source of radon exposure. From a sampling of homes during the feasibility phase of the study, 10% of the residences were found to have water with radon levels above 20,000 pCi/l and 10% with household air radon levels above 5 pCi/l. Sample size calculations indicate that a study of 600-800 female lung cancer cases and 800-1200 population-based comparison females should provide sufficient power to detect at least a relative risk of 1.6 where the prevalence of exposure is as previously noted. Lung cancer pathology will describe cell type for the case series. Sufficient incident cases should be acquired within three years. The power calculations and basic study protocol were reviewed at a workshop at the EPA Center for Environmental Epidemiology (University of Pittsburgh) in April 1985. At present, the OMB clearance package and final protocol are being prepared with field work scheduled to begin in March 1986.

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A 2: Continued

B. New Jersey: Residence histories will be obtained and radon will be measured in previous residences to determine radon exposures in a recently completed study of 1000 cases of lung cancer in females and 1000 population-based comparison subjects. Emphasis will be on collection of household radon exposure data for those who have been long-term residents in the state, especially the northern part where high radon levels have been found. Approximately 10 percent of the study population may be in the Reading Prong area of New Jersey. The radon component of the study is several years from completion, as state legislation must be passed to fund the collection of radon measurements. A study of similar size in males has been completed and may also be considered for radon measurement. The study is a collaborative effort between the State Health Agency and NCI.

C. Pennsylvania: This case-comparison study is funded by DOE and is being conducted by the Argonne National Laboratory. The study area is central and eastern Pennsylvania (excluding Philadelphia) in the Appalachian Mountain region where radon has been identified in a large number of homes. This area includes a population of 10,000,000 people residing primarily in small towns. A previous survey identified a mean radon level of 17.5 pCi/l in 20 percent of the homes in this area with the highest radon levels. Cases will be selected from 6855 lung cancer deaths which have occurred in the study area from 1973-85 (3746 are available for study). The field work will require five years. Approximately 900 smoking related and 1200 non-smoking related lung cancers in females are anticipated and this will comprise the case series. Cell types in lung cancer cases will be identified through pathology reports. Up to 3 comparison subjects per case will be selected. Based on available radon exposure data in the study area, this study should be of sufficient power to detect an association between lung cancer and environmental radon if one exists.

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A 2: Continued

D. Sweden: A case-comparison study of 200 cases of female lung cancer, 200 population-based comparison females, and 200 hospital-based females is underway to assess the risks of lung cancer from passive smoking. A radon exposure component will be included since high radon levels have been documented in Sweden. No estimated time of completion for this study was provided, but no results should be expected for at least two to three years.

F. Canada: A four-year case-comparison study of 1000 cases of lung cancer in both males and females and 2000 comparison subjects is in its second year. This is being conducted in the Winnipeg area where some of the highest radon levels in Canada have been measured. Although no data are available on anticipated radon exposures, the radon levels are likely to be lower than in the Maine and Pennsylvania studies.

EPA is coordinating our activities with other Federal studies by meeting with the other Federal agencies to discuss the design and protocols for each study.

The first meeting was held at the University of Pittsburgh Center for Environmental Epidemiology on October 1, 1985, and included most of the investigators conducting epidemiological studies of environmental radon exposures. All, except the Canadian study, focused on females for several reasons: 1) they are likely to have had longer and greater home exposures to radon, 2) there is less likelihood of confounding due to occupational exposures, and 3) there is likely to be a smaller percentage of smokers in this population. The participants at the meeting agreed upon a number of issues which might affect the comparison of study results, such as methods for measuring radon exposure, the collection of information on possible confounders, and latency period. We will likely convene a second workshop to review the progress of these studies within the next 6-9 months.

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A 2: Continued

Although all the planned epidemiology studies are of the case-comparison design, EPA's study differs from the others in that it is the only study considering drinking water as a possible source of exposure. Since one of the important premises in evaluating epidemiological data is to look for consistency among several studies we believe it is important for each of these studies to be conducted.

No single epidemiological study is likely to provide a definitive answer, and the results of an epidemiological study must be interpreted in the context of other epidemiological studies and other scientific information. This is a difficult area in which to do research because of the problems in locating effects and tracing them back to causes. It is scientifically preferable to have the different investigators agree upon certain aspects of study design and data collection so that the studies can be compared. The October 1 meeting at Pittsburgh was an important first step in this regard, especially for estimating radon exposure in the home and identifying the important potential confounding characteristics.

Q 3: Mr. Meyers also indicated in his testimony that EPA is planning research to check "hot spots". Does this work duplicate DOE efforts?

A 3: An important objective of EPA's radon program is the development of information which can be used to identify areas which may have highly elevated levels of radon in structures (i.e., "hot spots"). As part of a national assessment of radon in residential structures, EPA will study the relationship between geological and soil characteristics and indoor radon levels. In meeting this objective, EPA will use the results of DOE's research on the basic mechanisms for radon entry into buildings and other factors which influence radon levels in structures. EPA and DOE will continue to work closely together on this issue to ensure that each agency's efforts are complementary and that they will lead to the identification of high risk areas. The Interagency Committee on Indoor Air Quality (CIAQ) radon workgroup has been a forum for discussing these plans to ensure there is no duplication of effort.

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Q 4: Please describe the manner in which EPA coordinates its radon research with DOE. Are specific research projects jointly planned? Has DOE been given an opportunity to comment on proposed EPA radon projects?

A 4: Because DOE has had a long-standing radon program, EPA coordinates its research with DOE in many ways. One formal avenue of coordination is the Interagency Committee on Indoor Air Quality (CIAQ), which includes a radon workgroup co-chaired by DOE and EPA. This workgroup includes other interested Federal agencies such as the Tennessee Valley Authority, Bonneville Power Administration, and the Centers for Disease Control. Another formal avenue of coordination is the Committee for Interagency Radiation Research and Policy Coordination (CIRRPC) established by the Office of Science and Technology Policy (OSTP). EPA and DOE serve on both the Science Panel and the Radon Subpanel of CIRRPC; this representation has reinforced the coordination developed within the CIAQ radon workgroup.

DOE and EPA also communicate informally through the close lines of communication that have developed among staff at DOE's Office of Conservation and Renewable Energy, EPA's Office of Radiation Programs, DOE's Office of Energy Research, and EPA's Office of Research and Development. Frequent communication among the staff in these offices has enhanced the coordination of research, public information, and applied research programs. DOE and EPA senior management also discuss Federal agency activities through the CIAQ and on an informal basis.

In many of the DOE/EPA staff interactions and the interagency meetings, EPA has made it a point to describe its planned and current research and has received comments and suggestions from DOE and other agencies. This communication helps to ensure that the Federal projects are complementary and not duplicative. The different objectives of the two agencies help to assure this complementarity. In general, DOE efforts on radon are charactaerized by basic research whereas EPA's radon action program focuses on applied research and on the transfer of research information to both operational programs and activities, and to State and local government and the private sector.

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A 4: Continued

Specific examples of DOE/EPA coordination include: DOE's participation in a two-day EPA workshop on objectives for a national radon assessment; DOE's involvement during the development of EPA's strategies for radon activities on both a national level and also specifically in the Reading Prong; joint funding of work at Lawrence Berkeley Laboratory on important features of soil as a source of radon; DOE's assistance in the development and review of measurement protocols for indoor radon; and DOE's participation in the planning and implementation of a quality assurance program for indoor radon measurements.

In addition, staff on EPA projects to demonstrate low-cost mitigation techniques for radon are exchanging work plans and site visits with DOE staff on similar projects, especially those at the Bonneville Power Administration. This exchange of information and experience increases the number of geographical areas from which data on house types and mitigation effectiveness are available. A joint project on diagnostic mitigation studies at EPA project sites is also being planned.

Q. 9: What type of research would be necessary to identify those houses across the nation with indoor radon levels above 0.02 working levels (WL). Please describe how long such research would be expected to take and include an estimate of its cost.

A. 9: Because so many factors influence indoor radon levels, houses with levels above 0.02 WL can occur in almost any location. Therefore, it is unlikely that research efforts, per se, will lead to any easy way to identify all houses across the country with radon levels greater than 0.02 WL. Such levels are more likely to be identified only through large-scale measurement programs or surveys. The States will play an important role in any detailed investigations of potential high risk areas, and EPA will assist their efforts. In addition, research studies, such as a national assessment, should provide information which can expedite the identification of houses with levels significantly greater (i.e., an order of magnitude) than 0.02 WL by identifying factors associated with such levels. These research studies are part of EPA's overall radon action program.

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Q. 10: What is the present status of EPA's proposal to conduct a "national assessment" of indoor radon concentrations? What are the planned elements of the assessment? When can we expect preliminary results?

A. 10: EPA is now in the process of designing a national assessment of radon levels in residential structures which will involve three phases: logistical tasks and the testing of key elements of the study design; measurements and data collection; and analysis of data and presentation of results. The objectives of the assessment are (1) to determine the frequency distribution of radon in residential structures (i.e. the national distribution) and (2) to determine if associations exist between geological and soil structure features and radon levels in residential structures. Preliminary information hopefully will be available in two years.

Q 11: As research continues, it becomes apparent that high levels of radon are being found all over the nation, even in areas where there is no evidence that there are unusually rich concentrations of uranium in soil. How does this fact affect the ability to locate houses with elevated levels of radon.

A 11: Many factors influence indoor radon levels, including the concentration of uranium and radium in soils. Until the relationship between these factors is better understood, it is doubtful that we can predict the locations of all houses with elevated levels. EPA's current objectives for work on predictive techniques focus on identifying those areas in which homes with very elevated levels frequently occur (e.g., structures containing radon decay product levels near or greater than a tenth of a working level). Information gained from this effort, along with the results of various State, Federal and private measurement programs, will help improve our ability to locate homes with elevated levels.

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Q 13: Were any funds internally reprogrammed into indoor radon programs in FY 1985 or FY 1986? Are there any pending plans or proposals to reprogram funds into indoor radon programs? From which programs have these funds been reprogrammed?

A 13: A total of $2,550,000 has been reprogrammed to the indoor radon program from FY 1985 funds. These funds were generated from a wide variety of Agency sources from unexpended funds near or at the end of FY 1985, and were reprogrammed at the discretion of the Administrator based on his review of priorities, in cooperation with the Office of the Comptroller and the program offices.

Q 14: While EPA has achieved major concentration reductions in the demonstration projects in Pennsylvania some of the houses continue to have radon levels close to the .02 working level threshold. Does this suggest that it may be impossible to reduce radon levels below .02 working levels in some houses?

A 14: Of the 18 homes on which research mitigation has been installed, five have been reduced and remain below 0.02 working level (WL) using one of two successful techniques. (One home was above 7.0 WLs before mitigation.) The most successful mitigation technique is now being installed on the remaining homes of the original 18 in order hopefully to bring all below 0.02 WL. Some will undoubtedly be more difficult to successfully mitigate and some may be nearly impossible to take below 0.02WL. However, we hope that these can be successfully lowered in radon level.

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Q 15: What is the basis for EPA's decision touse 0.02 WL as the level at which mitigation is recommended?

A 15: EPA has not made or proposed a decision to use 0.02 WL as an official "action level" as part of our nonregulatory program to address naturally-occurring indoor radon exposures. However, 0.02 WL is the remedial action target for radon decay product exposures resulting from technologically-enhanced sources of radium (e.g., uranium mill tailings piles, reclaimed phosphate lands in Florida, and radium-contaminated Superfund sites).

The Agency's decision to use 0.02 WL as a remedial action level applies to several specific instances of technologically-enhanced radium concentrations. The action level was determined following the balancing of several parameters such as health risks, measurement uncertainties, and the cost and effectiveness of mitigation methods. More detail on the Agency's basis for the uranium mill tailings remedial action standard can be found in Attachment 1.[1] Details on the Agency's recommendations to the Governor of Florida are provided in Attachment 2.[2]

With respect to naturally-occurring levels of radon, a more pertinent question is: At what level does the EPA consider that action should be taken to reduce exposure to radon decay products that result from naturally-occurring sources?

Available evidence from studies of humans exposed to radon seem to indicate that risks are present for any exposure to radon and that the risk increases with exposure level and duration of exposure. Thus, the risks from even low levels of radon exposure should be of concern to public health officials. The Agency advocates the reduction of all exposures. This position will be also emphasized in the Agency's guidance to homeowners concerning radon exposures.

1. January 5, 1983, FEDERAL REGISTER, Part II, pages 590-606.

2. July 2, 1979, FEDERAL REGISTER, pages 38664-38670.

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In providing guidance to individuals on reducing radon exposures in their homes, the Agency is acutely aware of the need to provide reliable information so that homeowners will not spend money on unproven or unsuccessful techniques. Existing evidence supports the Agency's position that, in general, 0.02 WL is generally an achieveable goal, whereas reductions below this level are often not practical and sometimes not even possible. Therefore, 0.02 WL is currently considered a practical lower bound for the general case of radon mitigation. Additional work on mitigation techniques may indicate that lower indoor concentrations of radon decay products are achieveable in a cost-effective manner. However, since radon exists in outdoor air, indoor levels can not be reduced to zero.

Q 16: Does EPA believe that radon exposure below 0.02 WL is an acceptable level of risk?

Q 16: No. The acceptability of a given level of health risk from environmental exposure to a toxic contaminant depends very strongly on several characteristics of the particular environmental problem that is being addressed. These may include feasibility and costs of further reductions in the magnitude of individual risk and population risk, etc.

The hypothetical linear, nonthreshhold cancer risk model that EPA employs in its radon risk assessment decisions predicts potentially significant risks due to radon exposure to levels below 0.02 WL, depending on the time period for which exposure continues. Thus, the Agency does not support a position that exposures to 0.02 WL or below are "safe". However, for exposures to radon decay products from technologically-enhanced sources (e.g., uranium mill tailings, phosphate lands, or radium wastes) the 0.02 WL value was found to be an appropriate action level as a result of the balancing of risks and remediation costs. This balancing included the consideration and balancing of a number of factors (see the response to Question 15.)

Although the risk management process for the uranium mill tailings standard or the recommendations to the Governor of Florida did not result in a lower action level, the Agency does encourage the use of cost-effective techniques to reduce radon decay product levels to below 0.02 WL.

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Q 17: Even "normal" levels of indoor-radon may be associated with a risk of lung cancer hundreds or thousands of times higher than the 1 x 10-6 risk often used in risk management decisions in the area of toxic chemicals. Is there a reason to treat the risks of radon exposure differently than risks from other radioactive or toxic substances?

A 17: The EPA approaches environmental health problems with the same basic methodology for the risk management process. The management of risks generally considers several factors including the magnitude of individual and population risks, the feasibility of reducing risks, and the costs of risk reductions. The risk management decision then reflects the optimization of those factors. It is important to note that different types of environmental problems require that different data, facts, and options be considered for each factor.

For the indoor radon issue, an important fact to consider is the apparent infeasibility of reducing lifetime risks from indoor exposure to zero or even to the one in a million value mentioned in the question. There is a real and practical range of values for which mitigation is very costly or may not even be possible. Thus, solutions and objectives from the risk management process for radon are different from those for other problems such as toxic substances. Other features of the radon issue that affect the objectives of the radon program are:

1) Essentially all radon found in homes is produced by a naturally-occurring element. In general, the problem is not a direct result of activities by any one responsible party or group of parties. In contrast, most other environmental pollutants have a finite number of sources that are the result of human activity and can be controlled (such as during the manufacture or disposal processes).

2) The risk management approach for existing exposures to indoor radon is not regulatory. No single party or industry is responsible for the levels of radon that exist in homes. Furthermore, the decision on whether or not to conduct mitigation in a home depends on the individual homeowner. This is not the case for most other toxic materials addressed in Agency programs.

3) Mitigation methods are an important part of the risk management process. Methods of radon control involve changes to the individual structures (i.e. houses) or to air movement systems in the structures; this is typically not the case for other toxic substances.

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Q 18: How many homes in the country have levels of radon associated with increased lung cancer risk of 1 in 1,000 or greater?

A 18: Existing information on the distribution of indoor radon concentrations is not sufficient to precisely answer this question. However, one in one thousand is approximately the lifetime risk of lung cancer associated with average outdoor radon concentrations. Since outdoor concentrations represent the minimum concentrations inside houses, it is reasonable to assume that a majority, and perhaps most, of U.S. homes have concentrations of radon associated with an increased lung cancer risk of 1 in 1,000 or greater over a lifetime.

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Q 19: Would research on other indoor air pollutants be more costly if it was conducted separately from indoor radon research? Are there any special or unique characteristics of other indoor air pollutants that indicate that radon research should be conducted separately? If so, please describe those characteristics.

A 19: A portion of the research needs for indoor air pollution are common to all pollutants, but for the majority of work, projects are more clearly designed and administered for individual pollutants or groups of pollutants with similar characteristics. For example, information on ventilation and infiltration rates in structures, on the living and occupancy habits of individuals, and on the housing stock in the United States are all needed to address the problems posed by many indoor pollutants. However, for specific questions concerning pollutant source, mechanism of entry, methods of control, occurrence in U.S., housing stock, and health effects, the work needed to obtain answers is very different for different types of pollutants, including radon.

Most radon research is appropriately conducted separately from that for other pollutants; EPA believes that this is the most cost-effective way to conduct its indoor radon research. Several reasons for this position are:

1) Radon is the only indoor air pollutant for which its main sources (the soil surrounding the structure and/or the water supply) are outside the indoor environment.

2) The primary method of radon control involves changes to the house structure or design; this is typically not the case for other indoor pollutants.

3) Radon is measured using radiation-sensing devices that are quite different from the methods used to measure nonradioactive pollutants.

4) Health effects studies of radon require long-term follow-up of exposed populations in addition to the follow-up work on already exposed groups (underground miners); these study groups and designs are necessarily specific to radon and are not likely to be useful in studying the health effects of other indoor pollutants.

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5) Existing evidence indicates that the residential dwellings within one or two floors of ground level constitute perhaps the most important subset of housing stock that is involved in radon exposure problems. This subset may exclude dwellings (such as multi-floor apartment buildings) that are important to the information needs for other pollutants.

6) The sources and health effects of radon are relatively well known in comparison to other common indoor air pollutants.

7) Radon risk assessment is more advanced, allowing us to move faster to reduce large-scale risks if radon is treated as an independent entity.

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Q 20: What has the EPA done to draw on the substantial experience of European countries with respect to indoor radon? Has the EPA evaluated the "radon reservoir" developed in Sweden as a mitigation device? Has the EPA evaluated the survey and assessment data available in Sweden and Great Britain?

A 20: EPA is taking full advantage of the information on radon developed by various European countries, particularly Sweden. The Agency scientists and managers have participated in several international meetings to obtain the most recent scientific and policy information, and regularly correspond with scientists and policy makers from several countries, including the United Kingdom, the Commission on European Communities, Sweden, and Denmark, to exchange information and data.

It is interesting to note that the strategy developed by EPA to investigate and deal with radon problems is similar to the approach used by Sweden. Mr. Richard Guimond, the head of EPA's Radon Action Program, recently visited Sweden on a fact-finding mission with Senator Frank Lautenberg. The purpose of Mr. Guimond's visit was to speak with officials from several Swedish agencies and private groups to benefit from their successes and failures in various areas, such as in assessing exposure to radon, developing mitigation measures and guidance, and communicating with the public. Several of the mitigation techniques used in Sweden are being investigated by EPA, and may be evaluated if they have the potential for successful application in additional houses that we plan to study.

We have evaluated the survey data from Sweden and Great Britain, and levels in Sweden are generally higher than those in Great Britain. Both Sweden and Great Britain have completed national surveys, whereas, the overall U.S. survey is still in the planning stages. The limited U.S. data we have from Pennsylvania and New Jersey suggest that we may have a more serious problem than either our British or Swedish counterparts. The highest levels observed in Pennsylvania are about ten times the highest levels found in Sweden. Based on their survey, Sweden estimates that they have about 50,000 homes (out of 4,000,000) in the entire country greater than 0.10 WL (which would represent about a 1 in 10 chance of lung cancer) whereas, based on current survey data, there may be 35,000 homes (out of 300,000) with levels higher than 0.1 WL in the Reading Prong in Pennsylvania and New Jersey alone. We will continue to work closely with these and other countries to explore solutions to our common problems.

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Q 21: What has EPA done to examine radon contamination in drinking water?

A 21: The EPA has developed and analyzed the existing data concerning radon in drinking water. The Eastern Environmental Research Facility, a part of the Office of Radiation Programs in Montgomery, Alabama, in 1980-81 conducted a survey of radon in over 2500 public water supplies in the United States. Currently, the Office of Drinking Water is conducting a nationwide survey of 1000 public drinking water supplies for radon levels. The existing data from these surveys and other measurements have been analyzed and summarized in the proceedings of the National Workshop for Radioactivity in Drinking Water (May 1985 issue of Health Physics-see attached), the Office of Drinking Water's Health Criteria Document on Radon and in a paper to be published in the January 1986 issue of Health Physics entitled "Drinking-Water Contribution to Natural Background Radiation" (see attached). The Office of Drinking Water is in the process of developing the Revised National Primary Drinking Water Regulations. As a first step in this process, we are developing the Recommended Maximum Contaminant Levels (RMCL) for several radionuclides including radon.

EPA recently sponsored a workshop in Manchester, New Hampshire for northeast States and researchers which focused on radon and radon in water.

Also, EPA work to identify control techniques for radon in water includes a February 1984 report by EPA contractors titled "Evaluation of Waterborne Radon Impact on Indoor Air Quality and Assessment of Control Options".

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ENVIRONMENTAL DEFENSE FUND

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October 15, 1985

Rep. James H. Scheuer
2402 Rayburn House Office Building
Washington, D.C. 20515

Re: Radon in homes

Dear Rep. Scheuer:

The Environmental Defense Fund has identified radon in the home as one of the most serious environmental threats to public health. We are pleased that your committee has identified radon as a threat deserving high priority by the Congress.

In addition to the need to fund an EPA field survey to identify high risk areas, there is another critical issue that needs Congressional attention. I was especially distressed to hear members refer to EPA's action guidelines for radon as "safe" levels. Nothing could be further from the truth. EPA has set a .02 WL ("working level") standard as the clean-up target for radon in homes contaminated by radioactive wastes from uranium mills. According to the risk assessment EPA performed for that rulemaking, this standard continues to expose residents of these homes to a 1 in 65 chance of fatal lung cancer. This is not much less than the one chance in 25 that a smoker will get lung cancer. Not even EPA would go so far as to describe such a high risk as "safe."

It would be a tragedy to lull the American people into a false sense of security by leading them to believe that reducing radon to EPA's target-level will protect them. If there are 1 million homes with even more dangerous radon levels, and radon is lowered to EPA's standard, the 3.5 million Americans in those homes would still suffer 45,000 excess lung cancer deaths if EPA's risk assessment is correct. If Dr. Nero's lower risk estimate is correct, there would still be 18,000 out of these 3.5 million Americans who would die prematurely from lung cancer.

EDF hopes the Congress will not find this high level of risk acceptable. Prior to this Administration, EPA never found such extreme threats to health acceptable either. But under the leadership of Anne Burford and pressure from

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OMB, EPA abandoned the traditional public health goals that guided federal environmental policy for more than a decade. It is a dramatic new departure for the federal government to now declare a 1 in 65 risk of lung cancer "acceptable" for protecting public health.

If Congress now places a stamp of approval on EPA's residential radon standard as "safe," it would confirm the radical reversal in national health policy that has been introduced by EPA and OMB in the last three years. OMB has used this policy to undermine the health protections guaranteed by our air and water protection programs. Congressional endorsement of this policy would provide the final coup to OMB's quiet revolution that seeks administratively to overthrow our national environmental health laws.

EDF has documented this quiet revolution from the annals of EPA's decisions since 1983. The most frightening manifestation of it is the new standard Lee Thomas issued for radon emissions from uranium mines. EPA says the limit allows nearby residents a 1 in 25 chance of lung cancer. I've included a copy of the whole story.

EDF encourages you to move quickly to attack the radon-cancer time bomb that is ticking in thousands of homes. But as you move toward development of a program, also consider carefully what you think that program should accomplish. Reducing radon to EPA's target level will save some lives but it will leave many other victims unprotected. Please don't contribute to the grand illusion that will mislead most Americans into thinking that homes meeting EPA's standards are "safe."

EDF's Rocky Mountain Office has campaigned to reduce the hazards of radon from uranium mines and uranium fuel production. Now that the magnitude of the natural threat has become clear, EDF will do whatever we can to support your efforts to protect all Americans from this insidious threat. We support funding for EPA's national survey. But we also urge you to consider research aimed at identifying potential hot spots before homes are developed. While we must seek out and reduce high exposures in homes that are already built, in the long run, prevention may be the most effective policy.

If we can provide any other information or assist you in the months ahead, please contact me.

Sincerely,

Bob Yuhnke

Robert E. Yuhnke

Enclosures (2)

cc: Committee Members

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EPA 520/4/82/013-1
October 1982

Final
Environmental Impact Statement
for
Remedial Action Standards
for
Inactive Uranium Processing Sites
(40 CFR 192)

Volume I

Office of Radiation Programs
Environmental Protection Agency
Washington D.C. 20460

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TABLE 7-1. COSTS AND BENEFITS OF ALTERNATIVE CLEANUP STANDARDS FOR BUILDINGS
(in 1981 dollars)

Alternative Standards	Radon Decay Product Limit (WL)[a]	Number of Buildings Requiring Cleanup[b]	Total Cost (millions of) dollars)	Deaths Avoided (in first 30y)[c]	Estimated Residual Risk of Lung Cancer[d]
B1	0.015	370	11.5	65	0.8 in 100
B2	0.02	330	8.5	60	1.3 in 100
B3	0.005 (above background) to 0.02	420	9.0	65	1.3 in 100
B4	0.01 (above background) to 0.05 (above background)	350	9.5	55	5 in 100

[a]The specified value includes background unless otherwise noted. Background in Grand Junction is approximately 0.007 WL.

[b]See Section 3.4. For Alternative B4, which is identical to the Grand Junction criteria for action, we assumed the geometric mean of our two extreme estimates for the number of buildings requiring remedial action. Assuming the distribution of radon decay product levels will be the same as in Grand Junction, the number of buildings in the United States requiring action was adjusted for the other options.

[c]Based upon the relative risk model. Estimates based upon the absolute risk model are a factor of two lower. Health benefits attributable to reductions in gamma radiation levels are much smaller and have not been quantified.

[d]Lifetime risk to the individual living in a house at the radon decay product concentration limit. This risk is calculated after subtracting background from the level permitted by the standard.

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Vol. 4 No. 3 July 1985

The Environmental Forum

EPA's Risk Assessment Process... A Critique

by Bob Yuhnke

The Environmental Protection Agency under the Reagan Administration has radically reversed more than a decade of national public health policy committed to reducing or eliminating environmental cancer risks to the public.

Recent EPA decisions *not* to reduce public exposure to radiation from more than 300 sources around the country cap a string of actions substantially increasing the cancer risk to which the government will allow Americans to be exposed.*

This reversal of national policy is no doubt the most dramatic but least noticed change in environmental programs since 1970. It represents the abandonment of traditional public health goals in setting standards designed to protect the public from toxic air and water pollutants that cause cancer or incapacitating diseases.

Yet despite the life and death consequences of this policy reversal for millions of Americans, even Federal Register junkies addicted to their daily fix of bureaucratese would not have known of its occurrence had they not seen the front page of *The New York Times* on September 18, 1983. EPA's official pronouncements simply do not reveal the agency's unprecedented rejection of traditional criteria for determining the extent to which Americans can expect their government to protect them from known causes of environmentally induced cancer. The absence of any public notice of this dramatic reversal of environmental health policy raises serious questions regarding the Administration's motives, in addition to the wisdom of its decisions.

Prior to 1981, federal environmental standards limiting human exposure to air or water pollutants, food contaminants, and pesticides were typically set to reduce the risk of disease to one person in 1 million, or at most one in 100,000. But the radiation standards issued by then-EPA Administrator William Ruckelshaus in response to a contempt of court order this January will require *no* emission reductions from hundreds of radiation sources that EPA calculates are likely to increase fatal lung cancer risks ranging from one in 2000, to one in every 100 nearby residents. (49 Federal Register 43906, October 31, 1984, and 50 Federal Register 5190, February 6, 1985) Since the early days of the "Environmental Decade" in 1970, no Administration has found such increased risks acceptable.

Ruckelshaus' decision not to reduce public exposure to controllable radiation emissions follows the policy reversal first adopted by his predecessor, Anne

*Since after his confirmation as Administrator in 1983, William Ruckelshaus sought to make a sharp distinction between assessing the magnitude of health risks associated with exposure to toxic pollutants in the environment ("risk assessment") and the decision-making process that results in the selection of control options ("risk management"). Here the focus is on the development of risk management policy by EPA since 1983. For this purpose, EPA's assessments of the risks associated with the various pollutants regulated are accepted. EDF and other environmental organizations, along with experts in such fields as epidemiology and toxicology, have criticized EPA's risk assessments, but that is beyond the scope of this article.

"Risk" in this context is based on the probability that an individual will die prematurely as a result of exposure to a toxic pollutant. For different pollutants, the assessment of risk is subject to more or less uncertainty depending on available data. In the case of radiation, for example, lung cancer risks are based on 35 years of human exposure to radiation in the workplace, and from exposures in Hiroshima and Nagasaki. There continues to be uncertainty regarding the risk associated with radiation exposure. The uncertainties, however, are with those surrounding other pollutants for which the effects of human exposure have not been studied, or for which the studied exposures are of short duration. By accepting EPA's assessment of risks, this article necessarily accepts EPA's evaluation within the range of uncertainty described by the data. EPA's assessment for radiation, however, clearly does not adopt the highest estimates of risk which the data will reasonably support.

The risk of cancer attributed by EPA to environmental exposure to a pollutant is in addition to the incidence of that disease in the population as a whole. Thus the risk of lung cancer that EPA calculates for a person living near a uranium mill is in addition to the likelihood that the same individual would contract lung cancer if he or she did not live near a source of pollution, such as radiation, known to cause lung cancer. EPA does not consider "total" risk such as would result from assessing the cumulative risks associated with 1) airborne exposure from a nearby industrial source of radiation, 2) radiation that can accumulate in the home from natural sources, 3) medical exposure to radiation, and 4) exposure to other known causes of lung cancer such as smoking, asbestos, coke oven emissions, or diesel exhaust.

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". . . A policy that will, if not reversed, repeal by administrative fiat the health protection mandates of environmental laws enacted since 1970."

M. Burford. In 1983, standards set for the cleanup of radioactive wastes at abandoned uranium tailings dumps were estimated by EPA to allow a one-in-1,000 risk of fatal lung cancers for nearby residents. Ruckelshaus later issued another standard for the permanent disposal of radioactive wastes from uranium mills that allows the same high risk. Ruckelshaus' proposed standard for emissions of arsenic from copper smelters is estimated to allow one fatal cancer among every 100 exposed residents near the Tacoma smelter. In 1984 Ruckelshaus decided not to regulate a class of carcinogens known as polycyclic organic matter, even though EPA's own estimates indicate that about 800 Americans are likely to die each year from exposure to these pollutants. In addition, recent EPA guidance governing cleanups of toxic waste dumps would allow equally high risks to remain *after a site is declared safe*.

By contrast, the last standard set for a toxic air pollutant prior to 1981 reduced vinyl chloride emissions to a level designed to allow only a one-in-100,000 risk of liver cancer. The risks associated with general exposure to most approved pesticides and water quality criteria are also in this range or lower. The recent decisions to allow much higher risks in fact have few, if any, precedents. Together, these decisions reflect a policy that will, if not reversed, repeal by administrative fiat the health protection mandates of the Clean Air Act and other environmental laws enacted since 1970.

Congress never has defined an "acceptable" health risk under federal air and water pollution laws. But these laws clearly define a goal of preventing deaths caused by pollution and prohibit EPA from allowing deaths on the basis of estimated costs to industry or uncertainties regarding the feasibility of available control technology. This prohibition is based on the political decision to give human health the first priority, and to require polluters to bear the cost of meeting that priority. Congress assigned to American

Bob Yuhnke is Counsel for the Environmental Defense Fund in Denver. EDF has petitioned for review of EPA's decision to withdraw the radionuclide standards. This article is not to be construed as conceding that EPA has lawful discretion to allow high risks of lung cancer to remain unregulated.

"All the News That's Fit to Print"

The New York Times

.CXXXIII No. 45,895 NEW YORK, SUNDAY, SEPTEMBER 18, 1983

HIGHER RISKS SEEN IN NEW E.P.A. RULES

Agency Aides Say 2 Proposals Exceed Past Acceptability

Reagan's Campaign Advis... He Would Face Tough Ra...

U.S. WARSHIPS FIRE ON LEBANON AREA HELD BY DAMASCUS

Syrians React by Threatening to Retaliate if Their Forces Are Directly Assaulted

BOSTON ARCHBISHOP DIES...

Reagan Asserts

A front page September 1983 New York Times story, and not any formal EPA announcement, provided first notice of the agency's new approach to cancer risks.

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Congress has declined so far even to define just what constitutes an "acceptable" health risk under federal air and water pollution control laws.

industry the task of developing the affordable technological solutions needed to achieve the goal of protecting life. With rare exceptions, industry has met the challenge once emission-reduction goals were clearly defined.

The wisdom of this "technology-forcing" policy has been confirmed again and again since enactment of the Clean Air Act in 1970. Technologies not available then can now remove 95 percent of sulfur dioxide emissions from power plants, 94 percent of carbon monoxide from autos, and 99.9 percent of particulate matter from industrial stacks. These developments have occurred without substantial economic dislocation to the industries involved, and the national economy has benefited from the growth of new pollution control industries. Where necessary, as with autos and steel, Congress has eased compliance deadlines to allow time for introduction of new technologies. But Congress has never abandoned the Act's public health goals. For most industries regulated years ago, those goals now are being achieved.

In charting its new high risk policy, EPA has offered many and often contradictory reasons for its choice of regulatory options. But the agency has not engaged in a candid and public discussion of how the risks it has chosen to accept compare with similar decisions in the past. Nor has the agency attempted to initiate any public discussion of the obvious implications of its recent willingness to allow much higher risks to exposed populations. At bottom, it must be recognized that a decision to allow a population group to be exposed to a high risk of disease is a decision not to internalize within the polluting industry the cost of preventing that disease. The effect of EPA's high risk policy is to grant an indirect subsidy to polluters whose costs of pollution control are reduced in relation to other industries which are required to internalize more of the risk posed by their emissions. But unlike money from the U.S. treasury, this kind of subsidy is paid by those exposed to the risk, and the currency for payment is impaired health or loss of life.

EPA has not opened its standard-setting decisions to a candid consideration of the factors that must be weighed in determining how much and what kind of polluting activity justifies increased risks to health or loss of life. The Clean Air Act does not contemplate setting standards based on the concept that life is fungible and may be weighed in a balance against the economic value of polluting activities. Congress expressly directed EPA to set standards to protect public health with a margin of safety. The Act does not authorize EPA to weigh costs or speculate on the

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likelihood that technological innovation will provide cheap solutions. But EPA's recent decisions have cited a number of different cost and feasibility considerations as a basis for allowing high risks. If EPA intends to set standards as if it has authority to weigh costs or technology against risks of death, it has made no meaningful effort to alert the public and define the criteria it will consider in determining how many lives will be sacrificed.

Instead EPA has offered, in turn, a series of ambiguous or contradictory justifications for its decisions. In the first uranium tailings standard (48 Federal Register 590, January 5, 1983), EPA explained that its decision to abandon the Carter EPA proposal to "virtually eliminate" the residual risk from radiation was based on a policy of "optimizing" costs vs. benefits. The costs were quantified in careful detail, but benefits were barely addressed. The agency offered no analysis to explain why the costs of preventing the excess deaths allowed by the standard should not be paid.

"A decision not to internalize within the polluting industry the cost of preventing that disease."

The proposed arsenic standard (48 Federal Register 33112, July 20, 1983) focuses primarily on the feasibility of various control technologies, and it makes virtually no serious effort to estimate costs. It entirely ignores the technology-forcing policy that Congress built into the Act. As a result, EPA assumes that technologies currently installed in the U.S. are the only options. There is no recognition that historically the creative ingenuity of industry often has produced more effective and cheaper options than those deemed feasible *before* an industry had been regulated. The agency also ignored more effective controls in use in Japan. As a result the extent of public health protection is a factor of the technological status quo or the creative ingenuity of EPA staff. The agency's arsenic proposal needlessly puts life at risk because of an unwillingness to base public health policy primarily on the protection of life.

The first standard promulgated by EPA under Ruckelshaus allows a one-in-1,000 residual risk from radiation released after the closure of currently licensed uranium mills. It fails to impose any limits on the two-in-1,000 risk of fatal lung cancer from radiation emitted during the operation of a mill. (48 Federal Register 45926, October 7, 1983) The regulatory impact analysis prepared to accompany the rule contains a detailed cost-benefit analysis that shows that the most cost-effective option is the standard EPA adopted. At the point on the cost curve, the standard costs $80,000 per life saved. The option that would have "virtually eliminated" all risk, according to EPA, was rejected even though it would have cost only $120,000 per life saved. Despite this analysis, EPA's rule-making notice steered carefully away from the cost-benefit rationale the agency had adopted in the first uranium tailings rulemaking nine months before. The final rule-making notice instead relied on concerns that the more protective standard might not be technically feasible. These concerns had never been identified by EPA earlier in the rule-making. Although the final high risk standard was unchanged from the proposed standard, the proposal was based strictly on the cost-optimization rationale. The evidence to support the agency's new concern about feasibility was added to the record the day before the rule was released.

When the feasibility evidence was challenged in court on the ground that it had not been exposed to public scrutiny and comment, EPA reverted to its cost-optimization theory. But EPA has never explained why the costs associated with the standard most protective of health should not be paid, even though EPA concluded those costs would not put more than one small uranium mill out of business and would increase the average homeowner's cost of electricity by only 7.5 to nine cents per month.

In the benzene rulemaking, EPA was most explicit in its reliance on cost. (49 Federal Register 23498, June 6, 1984) The benzene standard was expressly selected on the basis of cost-effectiveness. The standard was set at the point on the cost-curve where the greatest number of health benefits were obtained per dollar invested in control. EPA conceded that more stringent, and more costly, options would protect more lives, but it did not explain why the cost of protecting more lives should not be paid. In the benzene rule, notions of economic theory prevailed over concern for protecting human life.

In benzene rule, the notions of economic theory prevailed over concern for protecting human life.

The rationale for the decision to withdraw the proposed radionuclides standards bears no obvious relationship to the decisions that came earlier. EPA disclaimed all reliance on cost considerations, and it argued that no standards were needed because the risks are insignificant. The increase in risk from some sources was as high as one-in-1,000. After a federal district court found EPA in contempt for failing to issue standards, EPA promulgated standards that allow current emissions to continue uncontrolled.

In EPA's earlier decision on uranium tailings, EPA allowed an equally high risk, but it at least conceded that such risks were high and expressed some official "discomfort" with setting standards at that level. The

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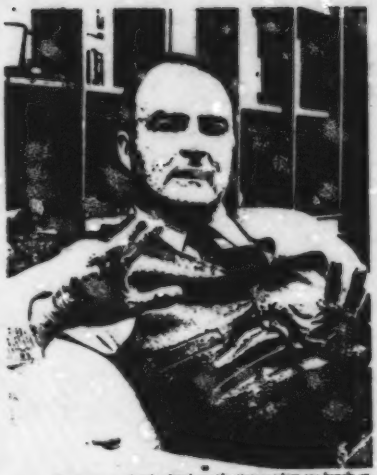

How assessment and political considerations weighing one heavily on Ruckelshaus when he was weighing 'insignificant' risks?

uranium tailings outcome was driven, the agency claimed, by cost or technology factors. For benzene, and in the 1976 vinyl chloride decision, the increased risk of death from exposure to uncontrolled emissions was only one-in-1,000 or less. These increased risks were considered unacceptably high and led to the adoption of standards that significantly reduced the risks. But in the radionuclides decision, the level of increased risk that had been considered unacceptable for benzene and vinyl chloride was simply dismissed as "not significant."

If applied to all EPA programs, EPA's new high risk policy would effectively abandon the nation's war against preventable environmental cancer. By failing to reduce public exposure to known causes of environmentally-induced cancer as EPA has done in the case of radiation sources, EPA is accepting the status quo.

The Surgeon General's 1982 report on lung cancer indicates that lung cancer is the fastest growing cause of death in America since 1950. The report also concludes that lung cancer is mostly caused by exposure to known carcinogens and is preventable. In the case of radiation, EPA has identified a cause of increased lung cancer risk and has chosen not to prevent the increased cancers.

Nonsmokers not occupationally exposed to carcinogens associated with lung cancer have a lower risk of lung cancer than the risk EPA found not to be significant in the radiation decision. For such persons living away from urban centers, the risk may be five to ten times less than the one-in-1,000 risk EPA decided not to reduce. But if such persons live near a nuclear fuel plant or other emitter of radiation EPA says pose no "significant risk," their risk of lung cancer would be two to 10 times higher than would otherwise be expected. In the case of the highest emitting sources, uranium mines and mills, the lung-cancer risk for non-smokers would approach the lung cancer risk for heavy smokers not exposed to radiation.

EPA's failure to reduce the risks to which these Americans are exposed imposes a heavy price on them. Assuming people are informed of the risks and have sufficient financial resources, they can move away. But aside from the option of uprooting their families and selling their homes, they have no control over the hazards to which they are exposed. People should not be forced to choose between high risks of cancer or dislocation.

EPA's conclusion that these high risks are not significant came without warning. The proposed rules for radionuclides not only concluded that the risks were significant, but also proposed standards that would have reduced exposure. (48 Federal Register 15076, April 6, 1983) The turn-around was not presaged by any public suggestion that the agency was about to make such a complete reversal on this fundamental issue.

Some within EPA leaked word that this decision was coming about two weeks before the court-ordered deadline for agency action. Traditionally closed-mouthed EPA staff were willing to share their dismay at the decision. A week before the decision was announced, I raised the issue directly with Ruckelshaus after the close of a meeting on another issue. "Were the rumors true?"

Ruckelshaus mentioned in response that key senators had threatened to remove EPA's rule-making authority over radiation, that the Science Advisory Board's (SAB) critique of the radionuclide risk assessment had undermined EPA's credibility in some circles, and that organizations such as the National Council on Radiation Protection were attempting to regain lost turf by using the SAB report to discredit EPA's science. He claimed he needed time to restore the credibility of the agency's risk assessment, time to respond to the SAB and perhaps receive its blessing on a revised assessment document, but he said he had no flexibility because of the court-ordered deadline.

In response, I told Ruckelshaus that the environmental community shared a very strong interest in preserving the agency's credibility in matters of science, and that the party to the deadline suit was willing to negotiate an extension of time provided it was clear that the additional time would be put to good use. He did not respond. The meeting was over. No overtures to negotiate an extension came in the days that followed. A week later it became, for the

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first time, the official policy of the U.S. government that increased risks as high as one in 1,000 are not significant.

As a result of Ruckelshaus' decision not to set radiation standards in October, he and EPA were held in contempt of court and ordered to set standards. In response, based on its judgment that the risks are insignificant, EPA adopted limits for many sources, including nuclear weapons plants and nuclear fuel facilities, that would allow radiation releases to rise from current levels. (50 F.R. 5190, February 6, 1985) For uranium mines, EPA concluded the increased lung cancer risk is high enough to justify limitations that would require emission reductions. (50 F.R. 7280, February 21, 1985)

EPA estimates the individual risks attributable to mine emissions to range from one in 100 to as high as one in 10 for persons living near multiple mine vents, and determined that as many as four excess lung cancer deaths would occur each year, depending on the rate of ore production. (50 F.R. 15386, April 17, 1985) But despite these high risks, the adopted mine standard will require only the use of a control technique that the industry already has applied on a limited voluntary basis. EPA says it has no basis for predicting the effectiveness of this technique, but estimates it will achieve only a 10 to 60 percent reduction in emissions. At best, the mine standard will reduce fatalities attributable to uranium mine emissions to between .5 and two per year. This standard reflects, more clearly than any other, EPA's willingness to sacrifice human life rather than implement the congressional policy of forcing industry to develop and apply control techniques capable of achieving the health protection goals of the Clean Air Act.

In retrospect, perhaps most disturbing about Ruckelshaus' response during the meeting was what he did *not* say. He did not express concern for the human costs, the suffering, pain, disruption of families, and the loss of loved ones that would be experienced by those exposed to the high risks he was about to declare "insignificant." After reflecting on the conversation, the most enduring impression is of a man so pressured by the institutional interests of the agency, badgering from Congress, the threats to EPA credibility, recurrent budget assaults by OMB, and a host of competing demands for EPA's attention that the interests of the affected public were not a significant part of the calculus, not weighed in balance.

Ruckelshaus' decisions and the recent uranium mine standard issued by Administrator Lee Thomas reflect a consistent policy by EPA on this question of acceptable risk that has remained unchanged under the three administrators who have held office since 1981.

The public expects that such fundamental national choices will be made in the political arena by politically accountable, elected officials, where the need for consensus, scrutiny by the press, and the sanction of the voting booth hold sway. But more and more, these fundamental choices that define our values as a people are being made by administrators who are not directly restrained by the traditional political process that governs consensus-building and legislating. Instead, administrators are governed by a political process that is less concerned with consensus, rarely scrutinized by the press, and often contemptuous of the known views or likely response of the public.

'People should not be forced to choose between high risks of cancer or dislocation.'

The lack of traditional political accountability places greater attention on the rule of law that governs administrative decisions and on the role of courts in holding administrative agencies accountable for their choices. While the system of checks and balances known as "administrative law" may serve well when the cooes to be made are technical applications of broader policy choices memorialized by statute, this system leaves much to be desired when the choices involve the fundamental values by which we shape the nation's future.

For this reason, the environmental community has fought to retain congressional control over the definition of the values that should govern the administrative process in setting environmental health standards. The Reagan Administration has repeatedly asked Congress for amendments to environmental protection laws to allow EPA to consider costs and other factors in setting environmental health standards. The Administration's demands have been couched in terms of "flexibility," "reasonableness," and "significant risks." But the history of the last two years of EPA standard-setting reveals clearly what the result of such flexibility would be. The bureaucracy should not be delegated ultimate authority for determining how many among us should be allowed to die from environmental hazards.

Each of EPA's recent standard-setting decisions is now being tested in court. In each case, environmental plaintiffs allege that EPA has overstepped its statutory bounds by making decisions that put life at risk in violation of congressional mandates to protect life. If the courts fail to vindicate the national priority that puts protection of life above costs to industry—and not on the same scale to be weighed in the balance—Congress once again will have to define the values that are to guide environmental standard-setting. □

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